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EVALUATION OF CHEMICAL EXPLOSIONS AND METHODS OF DISCRIMINATION FOR PRACTICAL SEISMIC MONITORING OF A CTBT

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This technical report has been reviewed and is approved for publication.

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13. ABSTRACT *(Maximum 200 words)*

Following a general introduction, our first annual technical report is in two parts. The first part, is an overall description of the data that we have acquired so far. We briefly characterize the status of our data collection efforts for twenty-four separate areas of the former Soviet Union. For those areas for which we have significant data, we give Tables and Figures characterizing our data. The second part, prepared and laid out as an independent stand-alone paper, is a discussion of the numbers of chemical explosions that are misidentified as earthquakes, in bulletins of natural seismicity (earthquake lists) for the territory of the former Soviet Union.

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GENERAL INTRODUCTION

Our goal in this project is to document the rates of occurrence of chemical explosions of different sizes, in as many mining regions as possible, but with a focus on the observability of blasting signals originating in the former Soviet Union, Australia, Canada, possibly China, Korea, and the U.S.

The size of a chemical explosion is expressed commonly in terms of charge size. But in this project we are more interested in size expressed in terms of seismic magnitude, whether local, regional, or teleseismic, since our concern is with the observability of blasting activity. We are particularly interested in estimating the numbers of chemical explosions that occur in different regions and that are detected teleseismically with $m_b > 3$. Underlying our work, is the fact that mine blast signals are less easily discriminated from nuclear explosion signals, than are earthquake signals, so mine blast signals may require more sophisticated analysis in programs of CTBT monitoring and verification. Therefore, large numbers of detectable mining blasts would represent a problem for those who must routinely identify the nature of seismic sources (earthquake, mining blast, underground nuclear explosion). Our project will help estimate the extent of this problem, by making surveys of the observability of mine blast signals of various sizes.

Prior to starting this project in June 1995, we had preliminary indications for the U.S. that, in practice, only around 10 to 30 mine blasts appeared to be detectable teleseismically with $m_b > 3$. This number was surprisingly low, since, using magnitude-yield relationships for contained single-fired tamped explosions, one would expect from knowledge of the amounts of chemical explosives used, that thousands of U.S. blasts would be teleseismically detectable each year by sensitive arrays (Richards *et al*, 1992; Richards, 1995). The REB during GSETT-3 has reported about one U.S. blast each week (E. Bergman, personal communication), confirming our preliminary indications for the U.S., concerning the low numbers of observable blast events.

In this first annual report, we focus on the former Soviet Union (FSU). For our FSU survey we have acquired six types of information, as follows:

- coordinates of active quarries and mines in the different regions of our study;
- lists of times at which representative blasts, and large blasts, occurred;
- information on total charge size, and, if possible, of blasting patterns
  (numbers of holes, charge size and timing of delays);
- regional magnitudes for mining blasts
  (often using the Russian K class as a measure of signal strength);
- information on the teleseismic observability of mining blasts; and
- pertinent seismograms, for our own analysis.

We expect to acquire information for 24 mining areas in the FSU, as listed in Table 0.1.

#	Region	Lat (°N)	Lon (°E)
1	APATITY	67-71	33-35
2	GULF of FINLAND	55-62	20-30
3	KURSK	50-53	35-38
4	UKRAINE	47-51	22-40
5	CARPATHIANS	45-50	20-30
6	KOMI	63-67	55-59
7	URALS	54-59	57-63
8	CRIMEA	44-45	34-35
9	ANAPA	36-38	44.5-45.5
10	NORTH CAUCASUS	42-45	38-43
11	GEORGIA (GRUZIA)	41-44	42-45
12	ARMENIA	39-42	44-47
13	AZERBAIJAN	38.5-39.5	46.3-47.7
14	AZGIR	45-55	45-59
15	SOUTH CENTRAL KAZAKHSTAN	40-45	67-73
16	SOUTHEAST KAZAKHSTAN	42-45	76-79
17	TADJIKISTAN	38-40	67-70
18	KUZBASS & ALTAI-SAYAN	52-56	86-93
19	BAIKAL	48-58	100-120
20	WESTERN SIBERIA	60-65	104-119
21	EASTERN SIBERIA	58-72	120-165
22	FAR EAST (PRIMORYE)	43-56	123-139
23	MAGADAN	59-64	140-165
24	CHUKOTKA	60-72	165-195

Table 0.1: The name and location of 24 areas of blasting activity in the former Soviet Union, for which we have data. (Our data in some cases is substantial, and in others is sketchy.) This report is organized principally as a description of the data we have obtained, and the associated analysis, for each of the regions listed above, taken in the above order. **Tables and Figures below are numbered to correspond with each of the 24 regions.**

For several of these areas, we have detailed information on several tens of specific quarries/mining operations, and on hundreds of specific mining blasts. For other areas, we have more limited information. For a small number of areas, we have no information to report at this time. For all of the FSU areas, we expect further information to be acquired and analyzed during our second year of work. The following section describes the status of our data in each area, and gives examples of significant data using Tables and Figures. This is followed by a stand-alone paper, the second part of our annual report, in which we describe the extent of the problem of chemical explosions being reported incorrectly as earthquakes, in what supposedly are bulletins of natural seismicity (i.e. earthquake lists), for different regions of the FSU.

OVERALL DESCRIPTION OF OUR DATA

As noted above, the data we have been able to obtain varies greatly for the 24 regions of the former Soviet Union that we studied. We now describe our data for each area:

1. *RUSSIA: KHIBINY MASSIF IN THE KOLA PENINSULA*
   (67-71° N, 33-34.3° E)

We have the list of 6 mines, with their coordinates and distances (17-33 km range) from the Apatity seismographic station (67.5686 N, 33.4050 E, elevation 175 m). Our list of 200 explosions from June 1991 to Sept. 1992 includes times, location in mine, the size of charge (from 3.5 to 1200 tons), and the amplitudes of the *Pg* wave at the Apatity station. The data (which are from NORSAR Scientific Report 2-94/95, Semiannual Technical Summary , Oct 1994-March 1995) were used to get the day-time distribution of blasts, the frequency of blast versus charge, energy class K, and the relation between charges and seismic energy, E_S. See Tables 1.1–1.2, and Figures 1.1–1.3.

2. *GULF of FINLAND, INCLUDING BALTIC COUNTRIES, ST. PETERSBURG DISTRICT AND SOUTHERN FINLAND*
   (55-62° N, 20-30° E)

The ISC Catalog 1964-1987 was used. We studied blasting activity particularly in the years 1967-1973, and during the day time (0800–1800 hours GMT). We obtained the distribution of seismicity at different times of day, and at different magnitudes. Three places were found: near Tallinn, Narva and Sortavala, where 110, 17 and 5 events, respectively, were identified as probable explosions, even though they were listed as earthquakes. See Table 2.1, and Figures 2.1–2.3.

3. *RUSSIA: KURSK MAGNETIC ANOMALY INDUSTRIAL REGION*
   (50-53° N, 35-38° E)

We have a list of 4 quarries/mines (see Table 3.1), and examples of large explosions (see Table 3.2). This region has recently been the subject of extensive study by Leith et al (1995) and Adushkin et al (1996). We are still in process of acquiring information on observability of blasts in this region.

4. *UKRAINE*

(47-51° N, 22-40° E)

We have the location of 27 major quarries and mines active in the years 1986-1990, and 24 examples of blasts of known latitude, longitude, origin time and total charge size. See Tables 4.1–4.3.

5. *CARPATHIANS (INCLUDING PARTS OF SOUTH-WESTERN UKRAINE, MOLDAVIA, AND ROMANIA)*

(45-50° N, 20-30° E)

This is a region with high natural seismicity. We use the ESSN and ISC Earthquake Catalogs for the years 1962-1990. By combining patterns of spatial seismicity with temporal patterns of events at active and quiet times of day, seven places of blasting were found and a list of 160 probable explosions with their origin time and location was created. See Table 5.1 and Figures 5.1–5.3. Further discussion of this region is given in the separate paper which concludes this first annual report.

6. *KOMI: NORTH-EASTERN PART OF RUSSIA*

(63-67° N, 55-59° E)

We are still in the process of acquiring information on blasting in the Komi region.

7. *CENTRAL URALS*

(54-59° N, 57-63° E)

We have a list with quarry/mine names, their location, and their distance from the IRIS/GSN/GSETT-3 station at Arti (ARU) in the Urals. See Tables 7.1–7.2, and Figure 7.1.

8. *CRIMEA*

(44-46° N, 32.5-37° E)

We have the location and names of three quarries on the south-eastern coast of the Black Sea. See Table 8.1.

9. *RUSSIA: Region around Anapa (N.W. Caucasus)*
(44.6-45.3° N, 36.5-38.0° E).

We have the day-time distribution of 247 events in the years 1968–1990. Of these, 205 occur in the narrow time interval 9-15 GMT (1200-1800 hours local time). We conclude that 92 % of them (about 190) are probably explosions. The cumulative seismicity, after presumed explosions are removed, does appear to have typical earthquake statistics. See Figures 9.1–9.2.

10. *NORTH CAUCASUS : AROUND KISLOVODSK AND ELBRUS MOUNTAIN*
(42-45° N, 38-47° E)

We have quarry/mine locations, and catalogs of blasts for several years.

We have a list of 450 explosions (1977-1984) with their origin time, their seismologically estimated coordinates and energy class K in the Tyrnaus mine, and distribution of blasts with time-of-day and day-of-week. Explosions at Tyrnaus couple more efficiently into seismic waves than do blasts in the Khibiny Massif. We understand from correspondence with local scientists, that around the Cherkeiskaya dam located at about (42.7-43° N, 46.7-47° E), about 30 % of events in in the local "earthquake" catalogs are in fact blasts. See Table 10.1 and Figures 10.1–10.2.

11. *GEORGIA (GRUZIA), SOUTHERN CAUCASUS*
(41-43° N, 40-46° E)

We have a catalog of 1270 blasts from the Mandeulsky quarry (1962-1988). We also have their distribution at different times of day, and for the Eastern Dzhavakhetia area. See Table 11.1 and Figures 11.1–11.2.

12. *ARMENIA*
(39-41.5° N; 43-46° E)

We have a list of 82 blasts in the Yerevan region obtained from the bulletin of this station in 1987, with the origin time, distance from Yerevan station (12-30 km), energy class K (5.5-8.1) and magnitude *mP* (a local scale). We have also tables of the distribution of 2341 blasts with time-of-day, recorded by the Yerevan station for 1985 and 1986, and the distribution of events in the range of K class 6.0 to 9.9 for each year during 1976-1988. We have also a list of 41 large explosions (K > 9), (from 1988, K > 8) in the whole Caucasus region, (40-43.5 N, 42.5-47 E) during 1972-1995. See Tables 12.1–12.3, and Figures 12.1–12.3.

13. *AZERBAIJAN*

(38-41.5° N, 45-50 E°)

We have the communication, that near the Khodaferinskaya dam on the Arax river (38.5-39.5 N, 46.3-47.7 E), where events are recorded by the Gebrail station 25 km from the dam, about 50 % of the detected events are explosions.

14. *AZGIR, AND THE CASPIAN DEPRESSION*

(45-55° N, 45-59° E)

We used NORSAR data for 184 explosions in the years 1972-1991 in this region. Their mb(NAO) ranged from 2.7-5.7. We prepared the distribution of them at different times of day and different magnitudes mb(NAO). We determined the relation between mb(NAO) and mb(ISC).

The data are only for part of the whole area. See Table 14.1 and Figures 14.1–14.2.

15. *KAZAKHSTAN, SOUTH CENTRAL REGION AROUND DZHAMBUL*

(41.5-44° N, 68-74° E)

We have a list of about 2130 blasts from June 1988 to Dec. 1991 with known date, source time, and energy class K. We have the distributions at different times of day and different energy classes. Table 15.1 lists 223 of the larger blasts ($K \geq 8.4$), and Figures 15.1–15.2 show the distribution of these blasts vs. time-of-day and vs. K-value. Note the result of Fig. 15.2, very commonly found for chemical explosions, that the cumulative distribution is much steeper (against K or magnitude) than is the distribution for earthquakes.

16. *KAZAKHSTAN, SOUTHEASTERN REGION (NORTH TIEN SHAN)*

42-46° N, 75-80° E).

We have a list of 27 quarries, a list of 5289 blasts during 1979-1994 with their K class but without coordinates, and a list of 94 large ($K > 7.9$) blasts, with coordinates or names of quarries (1972-1976). And we have the distribution of blasts at different times of day and different K class. See Tables 16.1–16.3 and Figures 16.1–16.7. Table 16.4 shows the annual number of quarry blasts in the region for a ten-year period(1985-1994) spanning the breakup of the Soviet Union. It is clear from this Table that blasting activity in Kazakhstan is currently much reduced from the levels reached during the Soviet era. We believe this reduction is likely also to have occurred in Russia and Ukraine.

17. *TADJIKISTAN*
(38-40° N, 67-70° E)

We have the location of two places where explosions occur, and the day time distribution for one of them for the period of special observation Feb. 1989-Aug. 1991. See Figure 17.1 (the peak in the distribution of events vs. local time-of-day indicates these events are mostly blasts).

18. *RUSSIA: ALTAI-SAYAN REGION, INCLUDING KUZBASS INDUSTRIAL AREA*
(52-56° N, 86-93° E).

We have a list of 23 quarry/mine locations and two lists of blasts. The first is a list of 803 blasts (January 1989-June 1992) with known epicenters and energy classes of explosions in the KUZBASS industrial area, 29 of them with $K \geq 10$, and 593 with K around 9. The other is a list of 392 blasts, recorded by the Cheremushki station at distances less than 120 km, with their origin time and K class. There are 6 blasts with $10.0 \leq K \leq 10.5$ and 85 with $9.0 \leq K \leq 9.9$. The distributions of events at different times of day and different K values were obtained.

The activity of different mines was compared with each other, and three mines in particular appear to be of great interest because they routinely carry out blasts large enough to be observed teleseismically. A network of seismographic stations still operates in the Altia-Sayan region, recording both earthquakes and large chemical explosions. We anticipate that this region will warrant further study, both in the context of research on regional discriminants, and in the context of operational needs to be confident that the large chemical explosions are as advertized. See Tables 18.1–18.5 and Figures 18.1–18.8.

19. *RUSSIA: BAIKAL REGION*
(48-58° N, 100-120° E)

We have a list of 76 quarries, and a list of 842 blasts from July to October 1991 and from June to October 1992. 322 of them have known charge size in the range 0.43-192 tons.

In Pribaikalye (the southern part of the region), the level of natural seismicity is very low. From analysis of the ESSN earthquake catalog (looking at the distribution of events at different times of day, together with their spatial distribution and magnitude distribution) an additional 6 places of blasting in Pribaikalye were found. We have prepared a list of 55 events in this region that are probably explosions, but included in the ESSN catalog as earthquakes. See Tables 19.1–19.6 and Figures 19.1–19.5.

20. *RUSSIA: WESTERN SIBERIA*
(60-65° N, 104-119° E).

13 epicenters were found, which were probably large chemical explosions (mb = 4-4.4). Such events will likely be detected and may result in the need for further investigation, if they occur after a CTBT enters into force. See Table 20.1 and Figure 20.1.

21. *RUSSIA: EASTERN SIBERIA, INCLUDING YAKUTIA*
(60-72° N, 115-165° E)

The ESSN, OBN and ISC Catalogs were used to find explosions which are included in the catalogs as earthquakes. Analyzing the spatial and day time distributions, seven small areas were found, within which events are probably explosions. We found 110 events listed as earthquakes that we believe to be blasts. See Table 21.1 and Figures 21.1–21.3.

22. *RUSSIA: THE FAR EAST REGION*
(PRIMORYE, 43.5-56° N, 123.5-138.5° E)

We have a map and a listing of quarry/mine locations, and lists of blast times and blasts signal strength. See Tables 22.1–22.3 and Figures 22.1–22.2.

23. *RUSSIA: MAGADANSKAYA OBLAST*
(60-70° N, 145-180° E)

This region partly overlaps the Eastern Siberia (22) and Chukotka (24) regions. We have data from W. Leith on location of quarry/mine places and a list of blasts with their time, charge (50-256 tons range) and location. We have distribution of blasts at different times of day and different charge size, and have searched without success for teleseismic data for the largest events. See Table 23.1.

24. *RUSSIA: CHUKOTKA, THE FURTHEST EAST PART OF ASIA*
(60-72° N, 165-190° E)

We have a day time distribution of about 780 blasting events near the Amguemskaya dam during 1986-1989. Analyzing the distribution of events at different times of day, and the spatial

distribution of small (K < 10) events in the years 1970-1990, about 61 more events at Amguemskaya dam and 64 around it (up to 300-400 km from the Yultin station) we discovered. 13 events that occurred at the dam area during 25 hours Aug. 26-28 1976, with K from 8 to 12 (i.e., up to magnitude around 5), all at the time of active blasting. These events could perhaps be induced seismicity, or very large explosions to create the dam. See Tables 24.1–24.2 and Figures 24.1–24.4.

Note that all Tables and Figures for this section of our first annual report appear following this page. A separate stand-alone paper, with its own set of Tables and Figures, concludes the report.

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Table 1.1. The list of Khibiny mines, at which industrial blasts occur that are detected routinely in Scandinavia.

Mine	Lat	Long	
I	67.6702	33.7285	undergr
I	67.655	33.744	open-pit
II	67.647	33.761	
III	67.631	33.385	
IV	67.624	33.896	
V	67.632	34.011	
VI	70.81	34.146	

Table 1.2. The list of Khibiny explosions ($Y \geq 100$ tons) with known charges Y, measured amplitudes A, and estimated energy class K.

Mine	Year	Mo	Da	Ho	Y	A(nm)	K
IV	1991	6	18	10	118	31	5.59
IV	1991	6	28	11	350	78	6.33
IV	1991	7	5	12	380	11	4.81
V	1991	7	9	10	242	18	5.50
V	1991	7	12	10	392	64	6.49
IV	1991	7	12	13	300	60	6.11
V	1991	7	26	8	275	27	5.82
IV	1991	7	26	13	430	100	6.52
IV	1991	7	30	15	105	43	5.86
I	1991	8	4	12	120	414	7.32
IV	1991	8	16	13	335	76	6.31
V	1991	8	23	8	263	92	6.78
V	1991	8	30	8	205	27	5.82
IV	1991	9	19	16	240	33	5.64
IV	1991	9	25	10	220	27	5.50
V	1991	9	27	8	185	40	6.13
V	1991	10	11	6	142	33	5.97
IV	1991	10	11	13	190	106	6.56
IV	1991	10	15	11	120	16	5.10
IV	1991	10	18	15	474	34	5.68
V	1991	10	25	10	180	32	5.95
V	1991	11	1	8	150	80	6.67
IV	1991	11	1	14	474	54	6.04
V	1991	11	14	11	155	33	5.97
V	1991	11	15	12	146	36	6.04
I	1991	11	17	4	150	212	6.79
III	1991	11	27	14	320	50	5.80
I	1991	12	8	8	167	144	6.49
III	1991	12	11	13	289	40	5.64
V	1991	12	13	8	256	36	6.04
IV	1991	12	13	13	180	48	5.95
IV	1991	12	17	10	100	38	5.77
V	1991	12	20	12	247	23	5.70
IV	1991	12	20	14	210	44	5.88
I	1991	12	22	7	239	304	7.08
IV	1991	12	27	12	270	18	5.17
III	1991	12	28	15	380	207	6.92
I	1991	12	31	8	205	205	6.78

Table 1.2

Mine	Year	Mo	Da	Ho	Y	A(nm)	K
IV	1992	1	10	14	250	50	5.98
IV	1992	1	24	12	151	20	5.25
I	1992	2	2	5	110	433	7.35
V	1992	2	7	8	280	99	6.83
I	1992	2	16	8	168	168	6.61
IV	1992	2	19	12	360	108	6.58
V	1992	2	21	8	320	57	6.40
V	1992	2	28	8	295	67	6.52
V	1992	3	13	15	273	58	6.40
V	1992	4	3	6	160	99	6.83
V	1992	4	10	9	199	92	6.78
IV	1992	4	10	9	320	45	5.89
IV	1992	4	17	10	413	78	6.33
IV	1992	4	24	11	310	32	5.64
III	1992	4	25	13	150	365	7.37
IV	1992	4	28	14	520	50	5.98
I	1992	5	1	3	150	603	7.62
IV	1992	5	5	10	100	36	5.71
IV	1992	5	8	11	347	22	5.32
IV	1992	5	15	11	524	30	5.57
II	1992	5	24	4	130	210	6.76
I	1992	5	24	4	125	45	5.59
IV	1992	5	29	11	310	29	5.53
I	1992	5	31	3	217	208	6.78
IV	1992	6	5	11	315	63	6.15
I	1992	6	7	3	108	200	6.76
IV	1992	6	10	14	300	46	5.91
V	1992	6	11	7	280	15	5.37
I	1992	7	5	4	110	200	6.76
IV	1992	7	10	10	350	48	5.95
I	1992	7	12	3	117	114	6.31
IV	1992	7	31	9	460	39	5.79
IV	1992	8	5	15	140	78	6.33
V	1992	8	28	6	160	33	5.97
IV	1992	8	28	11	290		
I	1992	8	30	3	150	524	7.51

Table 2.1. The list of events, contained in the ISC bulletins for years 1964 – 1987, that are probably explosions in the Gulf of Finland, 57-62°N, 22-30°E.

Year	Mo	Da	Ho	Mi	Sec	Lat	Long	Mb
Sortavala								
1964	10	22	10	25	21.0	61.75	28.75	
1966	9	7	10	3	33.0	61.30	27.80	
1967	10	25	11	54	32.0	61.40	29.80	
1968	9	21	11	30	12.0	61.90	29.70	
1969	10	14	11	52	0.0	61.70	29.30	
Narva								
1967	2	13	15	48	24.0	59.30	26.40	
1967	2	15	14	6	55.0	59.20	26.10	
1967	2	17	13	15	58.0	59.20	26.10	
1971	4	8	13	21	4.0	59.30	28.20	
1973	1	13	12	31	30.0	59.40	28.30	
1973	1	19	12	37	19.0	59.30	28.10	
1973	5	7	12	14	40.0	59.50	27.80	
1973	5	10	13	31	55.0	59.50	28.50	
1973	5	10	14	45	30.0	59.50	28.50	
1973	5	15	12	28	16.0	59.40	28.30	
1973	5	19	12	10	45.0	59.40	27.40	
1973	5	23	13	17	22.0	59.20	28.30	
1973	5	24	12	46	51.0	59.30	28.00	
1973	5	28	14	13	15.0	59.20	27.50	
1973	5	28	14	13	23.0	59.20	27.50	
1973	5	29	13	7	35.0	59.60	27.70	
1984	3	23	12	12	38.0	59.50	27.60	3.3
Tallinn								
1964	5	6	11	21	0.0	59.60	24.70	
1964	9	5	13	20	27.0	59.50	25.00	
1965	3	22	11	35	33.0	59.90	22.70	
1965	7	2	18	58	57.0	59.60	24.40	
1966	10	30	12	1	37.0	57.50	23.40	
1966	12	23	8	20	19.0	59.60	24.20	
1967	5	6	14	15	27.0	59.90	24.30	
1967	5	7	11	34	14.0	59.90	24.30	
1967	5	15	13	55	15.0	59.80	24.30	
1967	6	14	13	23	7.0	59.80	24.30	
1967	6	23	11	50	32.0	59.50	25.60	
1967	7	27	11	39	24.0	57.30	24.40	
1967	9	21	14	54	46.0	59.80	23.40	
1968	4	17	12	15	4.0	59.90	23.50	
1968	9	26	15	12	48.0	59.40	22.70	
1969	4	3	14	27	20.0	59.70	25.60	
1969	4	11	12	40	31.0	59.70	25.60	
1969	4	15	12	42	57.0	59.70	25.60	
1969	4	22	12	53	35.0	59.70	25.60	
1969	4	23	13	3	42.0	59.70	25.60	
1969	4	29	12	31	11.0	59.70	25.60	
1969	5	8	10	54	44.0	59.70	25.60	
1969	5	16	11	7	27.0	59.70	25.60	
1969	5	23	13	34	11.0	59.70	25.60	
1969	5	28	13	25	40.0	59.70	25.60	

Table 2.1

Year	Mo	Da	Ho	Mi	Sec	Lat	Long	Mb
1969	6	6	13	2	28.0	59.70	25.60	
1969	6	11	12	2	36.0	59.70	25.60	
1969	6	16	11	58	24.0	59.70	25.60	
1969	6	20	12	13	5.0	59.70	25.60	
1969	6	26	13	19	18.0	59.70	25.60	
1969	7	16	13	38	15.0	59.70	25.60	
1969	7	18	11	29	51.0	59.70	25.60	
1969	7	30	11	26	25.0	59.70	25.60	
1969	8	18	12	26	12.0	59.70	25.60	
1969	8	19	12	1	32.0	59.70	25.60	
1969	8	20	11	20	36.0	59.70	25.60	
1969	12	9	8	34	50.0	59.70	25.60	
1969	12	25	12	7	56.0	59.70	25.60	
1970	1	14	12	33	50.0	59.70	25.60	
1970	4	1	10	12	5.0	59.70	25.60	
1970	4	6	13	33	41.0	59.70	25.60	
1970	4	15	17	18	25.0	59.70	25.60	
1970	4	21	12	59	3.0	59.30	24.20	
1970	5	18	12	35	12.0	59.70	25.60	
1970	5	23	12	30	35.0	59.70	25.60	
1970	6	8	13	51	46.0	59.70	25.60	
1970	6	15	15	3	53.0	59.70	25.60	
1970	6	18	11	15	31.0	59.70	25.60	
1970	6	24	12	57	15.0	59.70	25.60	
1970	6	24	13	9	13.0	59.70	25.60	
1970	6	29	16	10	2.0	58.70	22.70	
1970	7	1	12	10	25.0	59.70	25.60	
1970	7	6	12	51	10.0	59.70	25.60	
1970	7	7	12	55	26.0	59.70	25.60	
1970	7	17	12	11	9.0	59.70	25.60	
1970	7	20	12	9	44.0	59.70	25.60	
1970	7	30	13	0	36.0	59.30	24.10	
1970	7	30	18	1	18.0	59.43	22.40	
1970	8	1	10	47	23.0	59.70	25.60	
1970	8	4	13	32	33.0	59.70	25.60	
1970	8	10	16	54	5.0	59.30	24.10	
1970	8	11	12	8	35.0	59.70	25.60	
1970	8	13	12	1	32.0	59.70	25.60	
1970	8	20	12	39	6.0	59.70	25.60	
1970	8	25	12	18	43.0	59.70	25.60	
1970	9	15	12	48	3.0	59.70	25.60	
1970	9	18	13	24	25.0	59.30	24.10	
1970	10	5	14	20	37.0	59.70	25.60	
1970	10	9	12	9	41.0	59.70	25.60	
1970	10	12	12	59	39.0	59.70	25.60	
1970	10	13	12	57	46.0	59.30	23.40	
1970	10	13	13	0	15.0	59.30	23.40	
1970	11	20	11	54	0.0	59.30	24.10	
1971	1	12	12	59	58.0	59.40	23.60	
1971	1	15	12	50	0.0	59.50	25.10	
1971	1	26	13	46	23.0	59.50	25.10	
1971	3	31	12	40	49.0	59.50	25.10	
1971	4	6	13	0	31.0	59.20	24.20	
1971	4	9	11	52	11.0	59.50	24.90	
1971	5	4	13	26	58.0	59.50	24.80	

Table 2.1

Year	Mo	Da	Ho	Mi	Sec	Lat	Long	Mb
1973	1	23	12	5	0.0	59.40	25.30	
1973	5	8	12	17	12.0	59.50	24.90	
1973	5	14	12	1	54.0	59.60	24.70	
1973	5	15	12	59	0.0	59.20	24.20	
1973	5	16	14	18	34.0	59.60	24.30	
1973	5	17	14	35	54.0	59.70	24.20	
1973	5	18	12	15	23.0	59.40	23.40	
1973	5	21	12	13	34.0	59.50	24.80	
1973	5	22	13	22	30.0	59.30	25.00	
1973	5	23	17	44	37.0	59.60	22.20	
1973	5	23	18	0	44.0	59.60	22.20	
1973	5	23	18	17	44.0	59.60	22.00	
1973	5	23	18	18	0.0	59.60	22.00	
1973	5	25	11	9	30.0	59.50	25.20	
1973	5	26	8	38	52.0	59.60	24.00	
1973	5	26	8	41	31.0	59.60	24.00	
1973	5	26	8	41	49.0	59.60	24.00	
1973	5	29	13	0	50.0	59.50	23.30	
1973	5	30	10	31	26.0	59.30	25.50	
1973	11	3	12	6	51.0	59.80	22.20	
1974	4	19	15	29	3.0	59.70	23.90	
1974	6	22	13	30	19.0	56.75	25.50	
1975	11	14	12	51	43.0	59.50	25.00	
1976	10	25	8	39	44.7	59.20	23.58	4.4
1976	11	8	10	17	5.0	59.60	23.20	
1978	3	26	15	48	42.3	59.43	23.64	
1981	6	22	18	53	19.6	59.73	22.42	
1982	7	10	8	28	39.0	59.40	23.70	

Table 3.1. The list of four major mines in the Kursk Magnetic Anomaly Region (see Leith et al, 1995; and Adushkin et al, 1996).

Name	N	E
Stoliensky GOK	51.33	37.67
Lebedinsky GOK	51.33	37.67
Gubkin	51.33	37.67
Mikhailovsky GOK	52.25	35.33

Table 3.2. Data on some powerful blasts (total charge size > 100 ton) at mines associated with the Kursk magnetic anomaly during Feb–June 1992; and some standard blasts during Aug 4 – Sep 8 1995.

Date	Time GMT	Charge ton	Mine
06.02.92	09:00	871	Lebedinsky GOK
21.02.92	09:00	1248	-"-
05.03.92	09:30	1110	-"-
19.03.92	09:00	979	-"-
02.04.92	08:00	1319	-"-
16.04.92	08:00	946	-"-
30.04.92	08:30	787	-"-
08.05.92	05:00	298	-"-
14.05.92	08:00	694	-"-
22.05.92	08:00	1222	-"-
11.06.92	08:22	1568	-"-
25.06.92	08:02	1273	-"-
18.08.94	09:00	318	-"-
04.08.95	10:08	-	Stoliensky GOK
18.08.95	09:57	-	Lebedinsky GOK
24.08.95	08:10	-	Lebedinsky GOK
02.08.95	~20:00	-	Gubkin
01.09.95	~08:00	-	Mikhailovsky GOK
01.09.95	10:00	-	Stoliensky GOK
22.09.95	20:00	-	Gubkin
07.09.95	08:31	-	Lebedinsky GOK
08.09.95	08:00	-	Mikhailovsky GOK

Table 4.1. The locations of 27 mines/quarries in Ukraine.

#	Name	Lat	Long
1	Komsomol'sk na Dnepre	49.1	33.75
2	UGOK	48.53	33.38
3	JUGOK	48.35	33.2
4	JUGOK-2	48.3	33.37
5	Petrov	47.55	33.55
6	INGOK	47.97	33.03
7	IGOK	48.15	32.82
8	Muchachevo	48.2	22.9
9	Hust	47.7	24.5
10	Spole	48.49	23.8
11	Kalush	48.84	24.8
12	Staro-Konstantino	49.49	26.95
13	Polonnoe	49.95	27.76
14	Letichev	49.06	27.47
15	Kostopol'	50.59	27.74
16	Rakitnoes-1	50.9	27.83
17	Rakitnoe-2	50.8	27.93
18	Korosten'	50.48	28.4
19	Berdichev	49.9	28.6
20	Popel'nja	49.84	29.5
21	Rakitna-1	49.67	30.6
22	Rakitna-2	49.68	30.77
23	Sosnovka	50.32	29.87
24	Brjanka	48.68	38.43
25	Dlovan	48.34	39.37
26	Volnovaha	47.28	36.37
27	Annovski	47.5	34.8

Table 4.2. List of mine/quarry blasts in Ukraine in 1987 with known charge size (Q).

#	N	E	Quarry	Date	GMT Time	Q, ton
1.	-	-	Pervomayski	18.07.87	15h01m	190.16
2.	47.5	34.8	Annovsky	19.06.87	15h00m	607.00
3.	49.1	33.8	Komsomolsky	19.06.87	12h00m	516.55
4.	50.5	28.4	NKGOK	30.06.87	12h00m	679.35
5.	48.3	33.4	YUGOK	30.06.87	13h50m	784.28
6.	48.3	33.4	YUGOK	8.07.87	12h00m	554.39
7.	49.1	33.8	Komsomolsky	10.07.87	12h00m	990.00
8.	48.0	33.0	NGOK	10.07.87	12h05m	737.51
9.	48.2	32.8	IGOK-2	11.07.87	15h01m	81.00
10.	49.1	33.8	Komsomolsky	17.07.87	12h10m	669.00
11.	47.5	34.8	Annovsky	17.07.87	15h00m	544.77
12.	49.1	33.8	Komsomolsky	24.07.87	12h00m	276.00
13.	48.0	33.0	INGOK	24.07.87	12h05m	714.37
14.	48.5	33.4	UGOK	25.07.87	15h00m	98.00
15.	48.3	33.4	YUGOK	29.07.87	12h00m	714.39
16.	47.6	33.6	Petrovsky	29.07.87	15h00m	42.00
17.	50.5	28.4	NKGOK-3	30.07.87	12h00m	741.24
18.	49.1	33.8	Komsomolsky	31.07.87	12h00m	482.00
19.	47.5	34.8	Annovsky	31.07.87	15h00m	574.59
20.	49.1	33.8	Komsomolsky	7.08.87	12h00m	270.00
21.	48.0	33.0	INGOK	7.08.87	12h05m	477.72
22.	48.2	32.8	IGOK-2	8.08.87	15h00m	18.00
23.	48.3	33.4	YUGOK	12.08.87	12h00m	582.00
24.	47.6	33.6	Petrovsky	12.08.87	15h00m	104.00

Table 4.3. The number of events vs. local time-of-day (GMT+3) in Ukrainian mines/quarries.

GMT+3	N	GMT+3	N
0-1	0	12-13	53
1-2	0	13-14	36
2-3	1	14-15	18
3-4	0	15-16	14
4-5	0	16-17	8
5-6	0	17-18	3
6-7	0	18-19	1
7-8	1	19-20	0
8-9	2	20-21	0
9-10	3	21-22	0
10-11	2	22-23	0
11-12	16	23-00	1

Table 5.1. A list of seismic events in the Carpathian Region which are probably explosions - located in areas A - G of Figure 5.2.

Year	Mo	Da	Ho	Mi	Sec	Lat	Long	K
1967	8	2	15	35	10.0	47.00	25.00	
1974	8	17	11	39	53.0	45.40	25.19	
1975	1	31	10	7	0.0	45.05	22.79	
1975	12	30	11	29	37.2	45.32	22.97	
1976	7	23	15	8	48.8	45.31	23.18	
1977	6	11	10	3	39.5	45.39	25.09	
1977	8	18	11	2	50.3	45.42	23.06	
1978	8	19	14	5	43.0	45.48	25.37	
1978	10	12	10	35	15.6	45.44	22.90	
1978	12	20	12	4	15.2	45.41	25.34	
1978	12	27	14	47	17.2	45.37	23.11	
1979	3	9	13	10	54.8	45.47	23.04	
1979	3	30	11	37	5.6	46.25	23.27	
1979	7	21	7	42	14.6	45.10	22.88	
1979	7	26	11	23	6.6	45.45	25.09	
1979	8	18	10	56	36.0	47.10	22.10	9
1979	9	6	15	26	17.7	45.23	22.91	
1979	10	12	11	57	15.1	47.03	22.07	
1980	1	31	12	20	33.5	45.31	22.98	
1980	5	23	10	45	59.4	45.22	23.00	
1981	3	6	14	45	21.7	45.45	25.14	
1981	3	6	15	27	59.7	45.21	23.08	
1981	4	2	9	4	32.6	45.20	23.13	
1981	6	19	11	37	1.4	46.34	22.92	
1981	7	7	11	57	57.5	46.34	22.93	
1981	7	24	14	29	51.8	45.40	25.43	
1981	9	5	6	59	43.1	47.00	22.11	9
1981	10	17	13	9	54.7	46.32	23.19	
1981	10	25	13	4	8.2	47.27	25.09	
1981	10	30	12	41	38.2	47.24	25.06	
1981	11	26	7	4	18.5	45.22	23.04	
1981	11	26	13	35	2.3	46.31	23.18	
1982	5	14	11	35	50.5	47.28	25.12	
1982	5	25	16	15	52.7	45.10	23.09	
1982	5	29	11	18	14.4	46.32	23.03	
1982	6	9	14	45	20.5	45.53	25.14	
1982	7	14	13	13	28.4	46.34	23.19	
1982	9	10	8	39	11.0	45.20	23.06	
1982	10	12	10	28	47.7	45.37	25.10	
1982	11	1	15	29	8.2	45.26	25.24	
1982	11	24	11	46	10.8	45.86	22.88	
1982	11	29	12	24	20.7	46.31	23.09	
1982	12	11	7	36	43.7	45.13	23.09	
1982	12	30	8	41	15.3	45.32	23.13	
1983	1	8	10	57	14.0	45.91	22.95	
1983	2	2	9	23	57.3	45.48	25.34	
1983	2	3	15	0	20.3	45.44	24.99	
1983	2	9	12	34	37.5	47.23	25.01	
1983	2	12	12	33	2.7	47.33	25.23	
1983	2	15	12	38	32.4	47.21	25.15	
1983	3	31	9	23	42.6	45.17	22.96	

Table 5.1

Year	Mo	Da	Ho	Mi	Sec	Lat	Long	K
1983	4	11	13	21	57.1	45.60	25.02	
1983	4	15	6	57	50.5	47.01	22.16	
1983	4	21	11	59	40.6	47.16	25.20	
1983	4	23	13	48	16.7	46.30	23.32	
1983	4	27	13	47	51.9	45.12	28.23	
1983	5	5	15	32	.7	45.31	25.37	
1983	5	27	15	28	33.1	45.29	25.06	
1983	5	29	11	27	33.9	47.01	25.08	
1983	6	2	11	9	28.5	45.41	25.33	
1983	7	4	15	13	33.6	45.56	25.38	
1983	7	21	15	1	10.3	45.06	22.99	
1983	8	4	12	18	41.3	47.33	25.11	
1983	8	7	11	40	1.7	47.32	25.20	
1983	8	16	11	33	12.4	47.07	25.17	
1983	8	20	13	37	39.3	46.31	23.12	
1983	8	31	11	43	51.3	47.01	25.13	
1983	9	12	10	29	16.8	45.91	22.95	
1983	9	14	15	26	47.3	46.28	23.22	
1983	9	27	15	46	35.6	45.13	23.11	
1983	9	29	15	43	44.1	45.34	25.08	
1983	10	1	12	41	59.1	47.18	25.16	
1983	10	9	12	17	6.1	45.86	22.93	
1983	10	25	14	17	54.9	46.44	23.21	
1983	11	6	12	35	12.7	46.99	25.15	
1983	11	22	12	39	.4	47.30	25.12	
1983	12	14	14	1	19.9	45.07	23.10	
1983	12	15	10	18	46.2	45.41	25.08	
1983	12	24	12	32	42.7	47.21	25.25	
1984	1	4	14	10	21.7	45.43	25.29	
1984	1	31	14	29	30.0	45.26	25.21	
1984	2	14	14	58	45.0	45.45	25.26	
1984	3	21	12	32	21.7	47.10	25.07	
1984	4	5	9	35	57.7	45.11	28.29	
1984	4	28	6	54	25.1	45.19	28.15	
1984	5	28	10	47	.2	45.37	25.39	
1984	5	28	16	31	6.0	45.21	25.20	
1984	6	26	11	44	22.1	47.05	25.11	
1984	7	21	11	48	7.3	45.96	22.81	
1984	7	27	11	59	36.7	46.24	23.25	
1984	7	31	13	57	38.7	45.46	25.12	
1984	8	1	11	3	29.0	45.97	22.80	
1984	8	4	11	33	40.4	46.37	23.11	
1984	8	13	10	48	29.7	45.21	23.03	
1984	8	13	11	29	15.5	45.45	25.23	
1984	9	8	15	48	27.8	45.41	25.48	
1984	9	19	11	34	58.1	46.01	22.83	
1984	9	22	6	11	58.7	45.18	28.22	
1984	9	26	15	0	19.0	45.35	25.27	
1984	10	25	10	31	9.6	45.02	28.27	
1984	11	3	12	52	19.1	46.32	23.18	
1984	11	6	12	10	42.9	46.44	23.23	
1984	11	7	12	38	32.7	47.17	25.13	
1984	11	17	12	34	10.1	46.99	25.07	
1984	11	30	9	19	36.5	45.24	22.90	
1984	12	1	11	46	19.5	46.03	22.95	

Table 5.1

Year	Mo	Da	Ho	Mi	Sec	Lat	Long	K
1984	12	20	12	42	40.3	47.12	25.18	
1984	12	20	14	34	33.0	45.32	25.10	
1985	2	1	6	50	46.1	45.39	25.30	
1985	2	6	12	27	9.0	45.26	23.08	
1985	3	5	11	31	27.9	45.82	22.89	
1985	3	13	14	18	22.1	45.24	23.06	
1985	3	14	12	21	58.9	46.25	23.19	
1985	4	22	15	28	22.4	45.37	25.27	
1985	4	26	10	58	22.1	47.08	22.06	
1985	5	17	13	40	31.7	45.21	25.17	
1985	7	4	14	30	38.5	45.20	25.30	
1985	7	11	11	0	8.0	47.03	22.16	
1985	7	23	14	20	21.0	45.07	28.18	
1985	7	30	14	17	34.4	45.42	25.04	
1985	9	4	9	40	30.1	45.40	25.33	
1985	9	5	13	47	28.8	45.17	28.20	
1985	9	10	14	17	49.4	45.16	22.98	
1985	9	13	15	50	43.2	45.43	25.07	
1985	9	27	13	34	54.0	45.98	22.79	
1985	10	4	13	44	43.7	46.46	23.01	
1985	10	21	13	15	11.2	46.17	23.09	
1985	11	5	15	16	41.3	45.55	25.37	
1985	11	8	12	50	41.3	45.83	22.90	
1985	11	11	14	58	35.9	45.40	25.12	
1985	11	22	11	57	1.3	47.04	22.14	
1986	1	24	14	8	50.5	45.44	25.18	
1986	3	15	8	46	15.8	45.31	27.83	
1986	3	20	10	11	41.9	47.23	25.09	
1986	4	5	13	45	18.9	45.39	25.34	
1986	4	18	11	58	45.4	45.17	28.00	
1986	4	25	8	15	40.8	45.03	28.38	
1986	5	7	11	45	7.3	47.01	25.22	
1986	5	9	14	43	27.0	45.13	28.30	
1986	6	3	11	49	13.1	45.47	25.43	
1986	7	16	11	15	11.7	45.87	23.04	
1986	7	25	11	30	19.3	46.08	22.74	
1986	7	31	16	6	28.2	45.50	25.46	
1986	8	20	14	2	12.2	45.40	22.88	
1986	9	18	7	43	39.0	45.03	22.98	
1986	10	24	12	55	3.8	45.30	25.35	
1987	1	23	11	55	23.1	45.17	28.15	
1987	2	20	15	41	49.1	45.46	25.08	
1987	3	6	15	18	31.3	45.14	23.06	
1987	4	28	14	20	2.0	45.43	25.35	
1987	4	30	11	33	41.2	45.39	25.41	
1987	5	5	16	8	10.4	45.35	25.16	
1987	5	5	16	8	48.0	45.40	25.10	8
1987	5	27	11	28	8.0	45.50	25.00	9
1987	6	17	7	47	52.0	46.04	22.73	
1987	6	27	7	53	44.9	45.54	25.31	
1987	7	1	15	59	16.3	45.40	25.16	
1987	8	11	15	29	33.2	45.55	25.24	
1987	8	12	12	2	51.3	45.45	25.32	
1987	8	28	9	26	40.1	45.13	23.05	

Table 7.1. Mine/quarry blasts in the Urals region (numbers refer to Table 7.2).

Date	Time	# Quarry
11-06	13-39-08.5	9
15-06	11-43-54.65	2
18-06	07-42-37.7	4
19-06	13-56-17.0	7
20-06	10-31-29.7	16
22-06	11-35-02.25	1
22-06	12-22-22.25	9
28-06	13-21-38.15	7
29-06	11-05-39.6	6
12-07	11-26-37.7	14
19-07	11-34-32.1	8
25-07	12-40-25.2	7
02-08	11-42-54.5	12
04-08	11-00-29.7	13
06-08	11-33-21.1	8
10-08	11-42-31.1	8
13-08	12-26-32.95	8
14-08	12-45-55.15	7
17-08	11-50-11.3	8
21-08	03-00-12.95	13
22-08	11-28-23.6	14
05-09	10-46-43.4	14
11-09	11-34-24.2	8
19-09	12-59-50.0	16

Table 7.2. Mines/quarries and their locations in the Urals region.

No/Name		Lat	Long
01	Bakal	54.91	58.8
02	Karagaika	55.09	58.99
03	Bolchegorski	55.09	59.09
04	Dinas	56.89	60
05	Pervouralsk	56.85	60.1
06	Shartash	56.8	60.86
07	Kurmanka	56.74	61.5
08	Asbest	56.97	61.7
08	Asbest	57	61.7
08	Asbest	57.02	61.74
08	Asbest	57.05	61.75
09	Suchoi Log	56.92	62.25
10	Novo-asbest	57.7	60.33
11	Gorbunovski	57.83	60.05
12	VGR	57.87	60
13	Lebyazhie	57.92	60.1
14	Alexandrovski	58.12	60.03
15	Kushva	58.24	59.92
16	Kachkanar	58.73	59.67
17	Gorno-zavodsk	58.4	58.43
18	Chusovoi	58.28	57.98
19		58.41	57.9
20		56.85	60.5
21		56.97	60.58
22		55.47	59.87
23		57.15	61.65
24		57.92	59.98
25		58.1	59.97

Table 8.1. Active mines/quarries in the Crimea.

No/Name	Lat	Long
Lozovoye	44.87	34.16
Mramornoye	44.95	34.21
Sharkha	44.68	34.3

Table 10.1. Quarries and mines near Kislovodsk.

Id #	Quarry name	Lat (°N)	Long (°E)	Id #	Quarry name	Lat (°N)	Long (°E)
1	Alenovsky	44.20	42.31	8	Tsementny-Zavod	44.11	42.04
2	Andezit	43.74	41.91	9	Tyrnauz†	43.39	42.87
3	Byely-Mramoz	43.48	41.76	10	Ust-Djeguta	44.09	42.02
4	Cher-Mramoz	43.56	41.79	11	Verblud	44.18	42.96
5	Zhako†	43.94	41.83	12	Zamok	43.89	42.62
6	Grznitny	43.35	42.19	13	Zmeika	44.18	43.11
7	Kinjal	44.27	43.01	14	Unidentified	43.50	43.91

(a) Based on local draft map

† F. Riviére-Barbier, Center for Seismic Studies, Washington D. C. (person. comm., March 1994).

Table 11.1. Mines/quarries in Georgia.

No/Name	Lat	Long
Madneul	41.22	44.28
Tkvibuli	42.59	44.79

Table 12.1 Active blasting locations and mines/quarries in Armenia.

No	Latitude N	Longitude E	Comments
1.	41.3-41.6	44.5-44.8	
2.	40.2-40.7	46.0-46.3	
3. Yerevan	40	44	
4. Kadjaran	39.1	46.10	1-2 bl. p/mo,40-50 tons
5. Agarak			1-2 bl. p/mo 25-35 tons
6. Sotk	40.22	45.99	1-3 bl. p/mo, 10-20 tons
7. Megradzor			1-2 blasts per month, <1 ton).

Table 12.2. Large blasts in and near Armenia, 1971-1995.

Ye	Date	Ho	Mi	sec Arr	sec Orig	K	Lat N	Long E	
72	26 12	04	08		57	9.0	43.00N	47.06	Dagestan
77	31 12	12	00		00	9.0	43.24N	43.06	Tyrnauz
80	21 01	07	57	18		9.2	Yerevan Reg		
81	27 12	07	44		21	10.2	43.21	42.50	Tyrnauz Q=1075 t.
84	7 01	08	27	46		9.4	Yerevan Reg		
84	7 05	08	46	35		9.2	Yerevan Reg		
84	31 08	12	19	11		9.2	Yerevan Reg		
84	4 09	09	00	27	01	10.4	39.10	45.46	Nakhichevan (Q=684 t)
84	20 09	13	20	06		9.9	Yerevan Reg		
84	9 10	12	30	09		9.3	Yerevan Reg		
84	16 12	10	00	36	07	10.0	42.33	43.41	
85	27 03	13	34	16		9.4	Yerevan Reg		
85	19 06	11	14	28		9.2	Yerevan Reg		
85	9 07	15	36	00		9.2	Yerevan Reg		
85	19 07	12	18	34		9.7	Yerevan Reg		
85	11 10	08	41	21		9.4	Yerevan Reg		
85	23 10	10	33	26		9.2	Yerevan Reg		
85	20 12	11	28	21		9.7	Yerevan Reg		
85	23 12	10	45	34		9.1			
85	26 12	13	23	27		9.3	Yerevan Reg		
86	25 03	13	55	05		9.6	Yerevan Reg		
86	26 03	10	34	57		9.3	Yerevan Reg		
86	27 03	12	59	06		9.2	Yerevan Reg		
86	3 04	12	10	37		9.3	Yerevan Reg		
87	14 01	13	53	46		9.3	Yerevan Reg		
88	29 01	12	27	53		9.2	Yerevan Reg		
89	7 06	12	58	14		9.2	Yerevan Reg		
89	16 11	12	31	56		9.3	Yerevan Reg		
90	7 02	10	57	39		9.8	Yerevan Reg		
91	4 04	13	39	52		9.6	Yerevan Reg		
91	11 04	10	23	23		9.2	Yerevan Reg		
91	16 06	04	54	07		9.7	Yerevan Reg		
91	27 06	14	09	08		9.2	Yerevan Reg		
91	21 11	09	09	59		9.3	Yerevan Reg		
92	27 03	10	17	23		8.9			
92	1 06	11	13	12		8.4			
92	4 06	11	14	21		9.1			
92	11 06	09	32	47		9.0			
92	29 07	12	10	56		8.4			
94	16 07	09	35	32		8.6			
95	19 05	10	29	14		8.6			

There were no large explosions (K>9.1) at 1992-1995.

Table 12.3. The distribution of blasts of different sizes in different years, occurring in and near Armenia (data taken from the bulletin of the Yerevan seismographic station).

K\Year	79	80	81	82	83	84	85	86	87	88	Total	EQ 63-89
6.0-6.9	21	19	134	105	26	53	24	74	35	24	515	
7.0-7.9	43	186	256	189	61	115	106	130	99	39	1224	
8.0-8.9	23	55	59	31	63	114	91	76	48	15	575	31
9.0-9.9	10	2	2	0	0	4	5	2	2	0	27	50
10.0-10.9												8
11.0-11.9												7
12.0-12.9												1
Total	97	262	451	325	150	286	226	282	184	78	2341	

Table 14.1. Chemical explosions in the Azgir and Orenburg regions.

Date			Time			Coordinates		Magnitudes mb			
Year	Mo	Da	Ho	Mi	Sec	Lat	Long	PDE	ISC	NAO	HFS
1972	7	1	5	24	50.0	48.10	45.10				
1972	7	3	20	25	57.0	48.00	45.30				
1972	7	14	14	59	49.0	49.99	46.38		3.7		
1972	7	27	15	30	20.0	48.00	48.00	3.4			
1972	7	31	14	21	21.0	47.30	49.30	3.6			
1972	10	2	9	9	38.0	50.80	51.30			3.1	
1972	10	21	11	50	54.0	50.10	52.60			3.3	
1972	10	22	11	47	45.0	52.60	51.60			3.2	
1973	2	13	12	58	10.0	47.30	45.90			3.1	
1973	4	27	15	9	55.0	53.40	51.60			3.2	
1973	5	26	8	36	24.0	47.60	46.10			3.0	
1973	6	23	3	21	32.0	51.30	52.10			3.1	
1973	6	23	18	38	36.0	53.10	51.20			2.8	
1973	7	12	8	39	40.0	51.80	52.80			2.8	
1973	7	19	16	18	29.0	48.00	49.70			3.8	
1973	7	21	7	15	45.0	51.40	52.50			3.4	
1973	7	29	11	59	41.0	49.00	49.60			3.5	
1973	8	2	21	8	56.0	49.20	49.70			2.8	
1973	8	4	16	10	54.0	53.80	52.10			3.1	
1973	8	15	0	34	5.0	51.10	51.70			2.9	
1973	8	16	6	50	36.0	51.20	50.50			2.8	
1973	8	30	14	52	7.0	50.90	50.60			3.1	
1973	9	1	18	0	36.0	51.30	50.20			3.4	
1973	9	5	10	17	19.0	49.00	49.60			3.6	
1973	9	29	14	43	59.0	50.90	51.70			3.1	
1973	10	5	5	48	35.0	52.20	50.20			3.0	
1973	10	22	5	18	30.0	51.40	51.30			3.0	
1973	10	26	6	0	2.0	53.80	54.90			4.9	
1974	5	27	12	15	53.0	46.00	45.90			3.7	
1974	6	5	10	14	42.0	46.70	45.60			3.2	
1974	6	5	18	15	48.0	48.80	47.90			3.0	
1974	6	16	12	23	39.5	49.41	49.08		3.6		
1974	6	30	11	41	32.0	54.10	50.60			2.7	
1974	7	1	16	49	27.0	54.20	50.90			2.8	
1974	7	16	9	2	29.0	45.60	59.00			3.2	
1974	7	25	20	47	54.0	51.90	51.50			3.4	
1974	8	9	19	9	45.0	48.10	48.00			3.1	
1974	8	14	18	22	53.0	54.90	51.10			2.7	
1974	9	3	13	55	42.9	47.58	47.16		4.1		
1974	9	15	7	27	49.0	49.00	48.60			3.0	
1974	9	27	14	22	39.0	50.20	52.60			3.4	
1974	9	28	10	21	31.0	49.41	47.60		3.9		
1974	9	28	10	21	32.0	50.30	50.00			3.7	
1974	9	29	11	11	2.0	53.50	50.90			3.0	
1974	10	2	15	37	45.0	52.40	51.20			3.0	
1974	10	4	15	42	5.0	49.00	48.60			3.2	
1974	10	12	5	58	16.0	48.80	47.90			3.0	

Table 14.1

Date			Time			Coordinates		Magnitudes mb			
Year	Mo	Da	Ho	Mi	Sec	Lat	Long	PDE	ISC	NAO	HFS
1974	10	12	10	47	53.0	54.90	50.20			2.9	
1974	10	13	9	9	56.0	53.10	53.80			3.3	
1974	10	21	12	39	56.0	52.50	53.30			3.1	
1974	11	23	17	42	32.0	52.70	54.90			3.3	
1974	12	20	12	39	56.0	47.40	47.40			3.5	
1974	12	28	1	36	51.0	47.00	49.60			3.3	
1975	2	8	13	40	2.0	46.30	49.00			3.4	
1975	3	22	12	50	25.0	48.50	47.30			3.3	
1975	6	6	8	57	58.0	48.30	46.80			2.9	
1975	6	10	11	0	8.0	50.10	50.90			3.2	
1975	7	17	6	11	54.0	49.20	45.30			2.8	
1975	7	26	12	15	22.1	49.94	48.68		4.0		
1975	7	29	6	47	27.0	49.20	48.30			3.1	
1975	8	6	1	22	52.0	52.80	53.30			3.0	
1975	8	7	3	7	37.0	48.70	48.10			2.9	
1975	9	1	2	2	13.0	52.00	55.00			3.1	
1975	9	20	4	39	42.0	49.40	47.20			3.1	
1975	9	24	4	51	49.0	48.60	46.90			3.4	
1975	9	25	13	3	8.0	49.00	45.60			3.1	
1975	9	30	13	35	18.0	52.50	53.30			3.3	
1975	10	21	12	34	43.0	50.00	50.70			4.0	
1975	11	25	12	52	9.0	50.40	50.70			3.6	
1975	12	13	10	34	49.0	53.00	52.90			3.1	
1975	12	25	22	9	13.0	50.37	54.30				
1976	1	1	10	43	0.0	48.90	47.40			3.3	
1976	1	9	10	40	44.0	47.90	49.00			3.2	
1976	3	20	10	29	20.0	51.40	51.30			2.9	
1976	5	24	9	36	49.0	51.20	50.10			2.8	
1976	5	28	15	51	35.0	52.00	50.80			3.2	
1976	6	8	7	37	25.0	47.90	49.00			3.2	
1976	6	16	13	33	59.0	48.10	46.70			3.2	
1976	6	26	11	2	4.1	50.33	51.02		3.8		
1976	7	16	16	25	26.0	49.40	49.60			3.6	
1976	8	16	9	34	51.0	46.40	45.40			2.9	
1976	9	6	11	2	44.0	45.70	47.50			3.9	
1976	9	20	11	51	21.0	50.00	47.20			3.2	
1977	10	5	12	43	17.0	48.00	48.00			3.5	
1977	10	14	7	0	2.0	48.00	48.00			3.9	
1978	5	8	2	53	31.0	52.00	55.00			3.2	
1978	9	14	4	0	2.0	51.20	53.20			3.6	
1978	9	23	6	12	55.0	48.00	48.00			3.6	
1978	11	1	20	2	15.0	52.00	55.00			4.3	
1979	8	15	20	7	16.0	52.00	55.00			3.4	
1979	11	29	18	27	28.0	48.00	48.00			3.6	
1980	7	7	2	46	40.0	52.00	55.00			3.2	
1980	7	24	7	37	14.9	49.88	47.72		3.9		
1980	8	29	4	0	9.0	48.90	47.00			3.7	
1980	8	29	15	36	1.0	48.00	48.00			3.5	
1981	4	25	2	42	4.0	52.00	55.00			3.1	
1981	4	30	22	45	29.0	52.00	55.00			3.3	
1981	5	26	6	0	22.0	48.00	48.00			3.4	

Table 14.1

Date			Time			Coordinates		Magnitudes mb			
Year	Mo	Da	Ho	Mi	Sec	Lat	Long	PDE	ISC	NAO	HFS
1981	5	26	8	0	21.0	48.00	48.00			3.3	
1981	6	22	9	0	21.0	48.40	49.00			3.5	
1982	2	5	23	12	37.0	52.90	52.90			3.6	
1982	10	1	13	9	52.0	47.20	49.20			4.3	
1983	2	1	13	55	1.0	49.30	48.60			3.8	
1983	2	24	14	11	24.0	47.00	46.90			4.1	
1983	2	25	6	52	55.0	47.10	46.50			4.0	
1983	3	2	8	45	30.0	48.20	48.50			3.8	
1983	4	29	15	25	18.0	46.90	48.20			3.8	
1983	6	4	5	47	40.0	48.00	49.30			4.4	
1983	6	24	7	42	56.0	48.80	46.80			3.6	
1983	7	2	10	37	14.0	47.00	46.90			3.8	
1983	9	29	9	22	33.0	46.30	48.80			4.1	
1983	9	30	4	11	49.7	48.69	46.28				
1983	12	18	5	18	57.0	50.10	50.20			3.5	
1984	4	28	14	53	48.0	46.20	45.80			4.5	
1984	6	1	6	55	16.0	45.60	46.20			4.0	
1984	6	19	18	25	45.0	49.00	46.20			3.3	
1984	6	29	3	57	25.0	49.10	47.00		4.1	3.9	
1984	7	1	6	35	25.0	49.80	45.50			3.3	
1984	8	3	12	49	36.0	46.90	46.50			3.8	
1984	8	13	23	38	24.0	53.90	50.70			3.4	
1984	9	19	0	28	56.0	48.90	49.80			4.0	
1984	12	2	10	57	13.4	45.75	48.89		4.1	4.0	4.1
1985	4	28	11	25	57.0	46.80	45.10			3.6	
1985	4	28	11	25	57.0	46.80	45.10			3.6	
1985	8	31	12	47	53.0	48.40	47.20			3.6	
1985	9	3	8	9	50.0	48.20	47.00			4.5	
1986	3	6	5	7	12.0	45.00	47.40				4.4
1986	3	6	8	37	51.0	45.50	46.50				4.3
1986	3	6	15	29	1.0	45.50	45.70				4.7
1986	3	7	2	22	21.0	45.40	46.30				4.6
1986	3	16	5	49	41.0	45.20	45.80				4.5
1986	3	18	3	43	28.0	47.20	47.40			3.6	
1986	3	23	14	26	54.0	45.10	45.90				5.1
1986	4	1	5	15	29.0	46.80	45.60			3.7	
1986	5	30	16	16	44.7	49.74	45.97		4.5		
1986	6	27	7	25	44.0	48.10	48.70			4.1	
1986	7	25	7	22	35.0	47.40	49.90			3.9	
1986	8	22	6	31	37.0	48.30	49.40			4.0	
1986	9	18	9	36	20.0	48.50	46.30			3.7	
1986	9	23	0	53	45.0	54.00	53.70			3.8	
1986	9	23	1	4	13.0	53.90	54.30			3.7	
1986	9	24	1	57	37.0	54.00	54.10			3.8	
1986	9	28	14	8	16.0	45.60	47.50			4.4	
1987	3	28	14	4	1.0	48.30	47.00			3.7	
1987	3	30	6	10	5.0	46.80	50.00			4.1	

Table 14.1

Date			Time			Coordinates		Magnitudes mb			
Year	Mo	Da	Ho	Mi	Sec	Lat	Long	PDE	ISC	NAO	HFS
1987	3	30	11	39	0.0	47.00	47.00			4.1	
1987	9	1	5	16	41.0	47.10	45.60			3.4	
1987	10	30	10	32	28.0	47.10	45.70			3.9	
1987	11	1	6	23	7.0	47.70	47.60			4.1	
1987	11	4	5	26	22.0	47.80	48.88			4.0	
1988	3	1	7	27	24.0	45.70	45.50			4.3	
1988	8	27	13	25	27.0	48.20	48.50			3.9	
1988	10	27	5	41	46.0	47.00	45.20			3.5	
1989	1	30	12	19	42.0	47.40	47.90			4.1	
1989	3	28	15	23	35.0	50.50	51.70			3.4	
1989	5	14	11	52	12.1	50.84	51.23	4.5			
1989	5	30	13	44	45.0	46.40	45.80			3.6	
1989	6	1	13	31	37.0	47.10	46.50			3.7	
1989	8	26	6	13	51.0	49.20	48.10			3.9	
1989	8	26	7	59	12.0	45.00	47.70			4.1	
1989	9	30	5	45	19.0	49.70	47.10			4.0	
1990	1	28	10	40	18.9	49.40	45.90				
1990	5	30	6	42	59.0	47.20	46.70			3.8	
1990	7	5	16	57	1.0	49.60	45.30			3.8	
1990	7	5	17	35	18.0	45.90	45.60			4.0	
1990	8	2	13	33	50.0	48.70	46.10			3.5	
1990	8	5	10	26	37.0	48.00	46.10			3.8	
1990	8	5	12	45	53.0	48.00	46.10			3.4	
1991	6	29	10	25	3.0	49.70	46.50			3.9	
1991	8	5	12	21	48.0	49.10	48.70			4.1	
1991	10	1	14	6	21.0	48.70	47.60			3.7	
1991	10	1	14	55	3.0	47.40	48.20			3.9	
1991	10	2	12	3	18.0	47.30	47.80			3.9	
1991	10	2	12	24	38.0	47.10	46.50			3.7	
1991	12	24	9	49	14.0	47.10	46.50			4.1	
1991	12	27	13	38	41.0	48.30	49.20			3.8	
1991	12	28	10	53	34.0	49.90	45.50			3.4	
1991	12	28	12	42	1.0	47.30	47.40			3.6	
1991	12	28	13	28	8.0	46.90	48.70			3.5	

Table 15.1. Chemical explosions in the Dzhambul region, K ≥ 8.5.

No	Date	Year	Time	K	
1	17.06	88	08-21	8.9	Tashkent
2	21.06	88	08-13	8.8	Tashkent
3	23.06	88	09-53	8.8	Tashkent
4	23.06	88	10-04	9.0	Tashkent
5	24.06	88	10-30	8.6	
6	29.06	88	10-00	8.5	
7	30.06	88	09-41	9.2	Tashkent
8	6.07	88	10-21	8.5	Tashkent
9	8.07	88	06-09	8.6	
10	8.07	88	09-29	8.5	
11	14.07	88	09-18	9.2	Tashkent
12	23.07	88	11-51	8.6	
13	26.07	88	09-18	9.2	
14	28.07	88	10-47	8.6	
15	9.08	88	09-49	8.9	
16	10.08	88	11-14	8.6	
17	12.08	88	09-32	8.8	
18	15.08	88	10-47	9.3	
19	17.08	88	02-33	8.7	
20	25.08	88	08-36	9.5	
21	2.09	88	09-16	8.8	
22	2.09	88	10-30	8.5	
23	7.09	88	10-17	8.9	
24	8.09	88	08-58	8.6	
25	26.09	88	18-12	10.2	
26	10.10	88	11-43	8.6	
27	12.10	88	11-20	8.6	
28	14.10	88	13-05	8.9	
29	14.10	88	13-29	8.5	
30	15.10	88	11-21	8.6	
31	17.10	88	09-34	9.4	
32	17.10	88	12-03	8.8	
33	22.10	88	10-14	9.0	
34	24.10	88	10-33	9.1	
35	11.11	88	10-30	10.5	
36	30.11	88	10-49	8.9	
37	1.12	88	10-21	8.8	
38	1.12	88	10-39	9.0	
39	6.12	88	06-54	8.6	
40	6.12	88	10-05	9.0	
41	15.12	88	09-19	8.5	
42	11.01	89	12-45	8.5	
43	14.01	89	11-11	8.5	
44	17.01	89	09-35	8.9	
45	18.01	89	08-01	8.5	
46	18.01	89	08-02	8.5	
47	18.01	89	09-05	8.5	
48	26.01	89	09-26	9.2	
49	10.02	89	11-57	8.6	
50	13.02	89	12-27	8.5	

Table 15.1

No	Date	Year	Time	K	
51	16.02	89	11-55	8.6	
52	21.02	89	14-02	9.3	
53	27.02	89	10-41	9.2	
54	7.03	89	10-28	8.9	
55	7.03	89	10-58	8.9	
56	16.03	89	11-34	8.6	Tashkent
57	24.03	89	09-43	9.0	
58	24.03	89	10-00	8.8	
59	24.03	89	10-00	8.9	
60	26.03	89	10-34	8.8	
61	29.03	89	10-44	9.1	
62	31.03	89	08-44	8.5	
63	31.03	89	09-36	8.5	
64	31.03	89	13-24	8.9	
65	3.04	89	10-32	8.7	
66	3.04	89	11-57	9.0	
67	4.04	89	10-25	9.0	
68	6.04	89	08-35	8.5	
69	7.04	89	09-12	8.9	
70	7.04	89	10-43	8.5	
71	10.04	89	09-45	8.7	
72	20.04	89	11-02	8.5	
73	27.04	89	07-33	8.6	
74	28.04	89	11-18	8.5	
75	12.05	89	07-57	9.4	
76	18.05	89	09-44	9.0	
77	22.05	89	12-33	9.4	
78	25.05	89	08-56	8.9	
79	26.05	89	08-07	10.5	
80	3.06	89	06-57	8.6	
81	8.06	89	09-27	9.2	
82	17.06	89	09-25	9.3	
83	20.06	89	07-10	8.9	
84	28.06	89	10-09	8.9	
85	5.07	89	09-35	8.5	Tashkent
86	6.07	89	12-34	9.2	
87	13.07	89	09-22	8.6	Tashkent
88	13.07	89	09-22	9.9	Tashkent
89	14.07	89	11-29	9.5	
90	22.07	89	06-51	8.8	
91	25.07	89	09-55	8.5	
92	27.07	89	09-43	8.5	
93	28.07	89	06-32	9.0	
94	28.07	89	12-02	8.9	
95	3.08	89	09-25	9.5	
96	8.08	89	09-08	8.7	
97	8.08	89	09-25	8.9	
98	10.08	89	11-54	8.5	
99	18.08	89	09-01	8.9	

Table 15.1

No	Date	Year	Time	K
100	24.08	89	09-48	8.6
101	29.08	89	08-14	8.5
102	20.09	89	08-29	10.6
103	6.10	89	00-29	8.9
104	20.10	89	11-51	10.1
105	25.10	89	07-14	8.6
106	10.11	89	12-09	8.5
107	11.11	89	10-31	8.6
108	14.11	89	09-08	8.5
109	15.11	89	10-26	8.9
110	15.11	89	13-00	8.5
111	21.11	89	09-45	9.0
112	21.11	89	09-46	8.9
113	22.11	89	09-43	8.7
114	24.11	89	10-08	9.1
115	27.11	89	10-29	8.5
116	7.12	89	10-39	8.9
117	8.12	89	09-38	8.6
118	15.12	89	11-04	8.5
119	21.12	89	10-25	8.5
120	21.12	89	10-26	9.0
121	22.12	89	08-02	9.0
122	27.12	89	11-19	8.5
123	29.12	89	11-28	8.6
124	6.01	90	08-51	9.8
125	18.01	90	11-15	9.1
126	22.01	90	09-55	9.4
127	26.01	90	01-21	8.9
128	27.01	90	10-41	8.9
129	30.01	90	09-14	8.5
130	30.01	90	10-36	9.3
131	3.02	90	10-08	8.9
132	6.02	90	09-38	8.5
133	8.02	90	10-51	8.6
134	8.02	90	10-51	9.6
135	9.02	90	10-33	9.1
136	12.02	90	07-07	8.8
137	22.02	90	11-42	9.7
138	26.02	90	11-56	8.6
139	27.02	90	11-04	9.0
140	1.03	90	03-49	9.0
141	1.03	90	10-28	9.0
142	1.03	90	10-36	8.5
143	7.03	90	08-57	8.9
144	23.03	90	09-52	8.9
145	23.03	90	09-54	8.6
146	24.03	90	08-13	8.5
147	24.03	90	10-16	8.8

Table 15.1

No	Date	Year	Time	K	
148	24.03	90	13-24	8.8	
149	6.04	90	09-36	9.0	
150	7.04	90	12-09	9.3	
151	13.04	90	10-17	9.2	
152	7.05	90	06-10	8.6	
153	7.05	90	10-01	8.5	
154	7.05	90	10-13	8.7	
155	7.05	90	12-08	9.3	
156	15.05	90	09-24	8.6	
157	23.05	90	13-59	8.6	
158	29.05	90	00-04	8.8	
159	29.05	90	09-17	8.5	
160	30.05	90	10-16	9.2	
161	20.06	90	12-46	8.5	
162	4.07	90	09-25	8.5	
163	11.07	90	10-55	8.6	
164	14.07	90	09-23	8.5	
165	30.07	90	11-06	8.8	Tashkent
166	2.08	90	04-41	9.4	
167	11.09	90	09-23	9.0	
168	15.09	90	08-11	9.2	
169	21.09	90	11-06	8.7	
170	11.10	90	08-33	9.5	
171	13.11	90	10-54	9.6	
172	17.11	90	07-45	9.3	
173	20.11	90	12-26	9.5	
174	4.12	90	09-25	8.5	
175	6.12	90	11-16	9.0	Tashkent
176	3.01	91	10-19	8.5	Tashkent
177	4.01	91	10-48	9.0	Tashkent
178	11.01	91	09-35	8.8	Tashkent
179	15.01	91	07-27	8.9	Tashkent
180	16.01	91	09-57	8.6	Tashkent
181	18.01	91	10-06	8.8	
182	31.01	91	06-47	8.5	Tashkent
183	13.02	91	10-21	8.5	
184	1.03	91	09-44	8.8	Tashkent
185	1.03	91	09-45	8.5	Tashkent
186	1.03	91	10-05	8.7	
187	7.03	91	09-59	8.5	
188	20.03	91	11-56	8.9	
189	4.04	91	11-36	8.7	
190	4.04	91	12-16	8.6	
191	9.04	91	10-59	8.6	
192	10.04	91	10-58	9.2	
193	16.05	91	10-01	8.6	
194	30.05	91	08-58	8.6	
195	5.06	91	06-38	9.1	
196	2.07	91	09-07	8.4	
197	5.07	91	09-09	8.5	
198	9.07	91	10-38	8.7	

Table 15.1

No	Date	Year	Time	K	
199	9.07	91	12-50	8.9	
200	11.07	91	10-03	9.6	
201	12.07	91	09-00	8.9	
202	12.07	91	09-09	9.4	
203	16.07	91	10-04	9.6	
204	17.07	91	15-12	9.1	
205	18.07	91	10-14	8.8	
206	19.07	91	09-38	8.8	
207	29.07	91	10-45	8.4	
208	30.07	91	08-12	8.6	
209	14.09	91	09-54	8.5	
210	10.10	91	09-17	8.4	
211	14.10	91	11-38	8.5	
212	18.10	91	06-41	9.5	
213	23.10	91	11-50	8.7	
214	28.10	91	11-54	9.3	
215	8.11	91	12-37	8.5	
216	12.11	91	10-49	8.6	
217	3.12	91	07-57	9.5	Tashkent
218	3.12	91	09-44	8.9	
219	5.12	91	10-16	9.2	
220	5.12	91	11-46	8.8	
221	9.12	91	08-31	9.0	Tashkent
222	13.12	91	11-13	8.8	
223	25.12	91	16-13	8.5	

Table 16.1. The list of active mines/quarries in the Eastern and Central parts of South Kazakhstan.

#	Name of quarry	Lat	Long
1.	AKTYZ	43.88	76.08
2.	ARAL`SKY	41.81	74.32
3.	Algatassky ALA-ARCHA	43.05	74.91
4.	BARTOGUY	43.43	78.59
5.	BOOM	42.50	75.95
6.	CHILIK	43.43	78.10
7.	CHON-KEMIN	42.95	77.02
8.	GEORGIEVKA	43.03	74.43
9.	ILI (or Iliyski)....	43.85	77.03
10.	ISSIK	43.37	77.48
11.	FRUNZE(Frunzensky)	43.93	74.88
12.	KAPCHAGUY	43.92	77.08
13.	KEN-SU	42.31	79.13
14.	KOK-SU	44.66	78.88
15.	KOTUR-BULAK	43.25	77.10
16.	KURMENTY	42.87	77.93
17.	KURTY	43.80	76.43
18.	KYZYL-AGACH	45.28	78.79
19.	MEDEO	43.17	77.08
20.	SAYAK	46.88-47.00	77.24-77.40
21.	SARI - OZEK	44.39	78.04
22.	TEKELI	44.78-44.85	78.88-78.97
23.	RUDNIK ZAPADNIY	44.83	78.88
24.	ZHANATAS (DZHAMBUL)	43.57	69.78
25.	(North from Almaty)	43.33	77.01
26.	(N-W from Almaty)	43.55	76.77
27.	(S-W from Almaty)	43.18	76.90
28.	(Western Kungey Rg)	42.87	76.73

Table 16.2. Chemical explosions in the Eastern Kazakhstan region, $K \geq 8.0$ (data from H. Mikhailova -- personal communication).

Year	Mo	Da	Time	K	Zone
1988	1	8	05-26	8.3	
88	1	14	12-42	8.0	
88	1	23	09-39	8.4	
88	1	27	10-24	8.0	
88	1	28	06-47	8.4	
88	1	28	12-16	8.6	
88	2	2	06-11	8.0	
88	2	2	10-39	8.5	
88	2	2	17-30	8.4	
88	2	10	01-57	8.0	
88	2	15	17-54	8.4	
88	2	16	10-23	8.2	
88	2	20	11-55	8.0	
88	3	3	12-13	8.0	
88	3	4	10-50	8.1	
88	3	11	11-23	9.4	
88	3	11	12-29	8.5	
88	3	21	11-29	8.6	
88	3	24	10-56	8.2	
88	4	3	06-15	8.0	
88	4	18	10-49	8.0	
88	4	22	11-29	8.0	
88	4	30	14-17	8.0	
88	5	3	12-52	9.4	Sayak
88	5	6	03-24	8.2	
88	5	11	06-58	8.7	
88	5	13	10-52	8.4	
88	5	19	10-23	8.6	
88	5	26	08-30	8.8	
88	6	4	08-33	8.3	Aktuz
88	6	7	10-37	8.2	
88	7	1	03-56	8.0	Kotur-Bulak
88	7	7	16-07	8.0	Kurty
88	7	9	12-13	8.0	Kurty
88	7	10	13-30	8.0	Kurty
88	7	12	18-49	8.8	Kurty
88	7	12	18-50	8.6	Kurty
88	7	12	18-56	8.7	Kurty
88	7	13	13-06	9.6	
88	7	13	23-40	8.5	
88	7	14	00-08	8.0	
88	7	15	12-37	8.0	
88	7	18	11-15	8.3	
88	7	23	05-44	8.7	
88	8	8	02-26	8.4	
88	8	18	03-09	8.0	Kotur-Bulak

Table 16.2

Year	Mo	Da	Time	K	Zone
88	8	25	10-51	8.7	
88	9	3	05-46	8.0	
88	9	3	06-57	8.2	Aktuz
88	9	10	08-43	9.3	Boom
88	9	15	01-57	9.0	
88	9	15	11-22	8.3	
88	9	24	12-11	8.7	
88	10	3	08-27	8.2	
88	10	12	10-47	8.3	Georg
88	10	14	10-21	8.0	Aktuz
88	10	15	21-43	9.0	
88	10	16	07-08	9.0	Sayak
88	10	16	11-33	8.5	
88	10	21	03-24	9.0	
88	10	23	16-45	9.1	
88	10	26	10-21	8.2	
88	11	10	10-33	8.1	Aktuz
88	11	15	09-41	8.0	
88	11	16	10-56	8.5	Aktuz
88	11	17	03-29	8.0	
88	11	18	12-47	9.4	
88	12	6	06-54	8.6	
88	12	7	09-57	8.0	
88	12	10	11-34	8.2	
88	12	12	11-02	8.0	
88	12	13	10-24	8.2	
1989	1	4	11-13	8.0	
89	1	13	10-34	8.5	
89	1	14	09-47	8.0	Aktuz
89	1	15	10-14	8.0	
89	1	20	11-13	8.7	
89	2	2	10-12	8.5	
89	2	3	07-23	8.9	Kotur-Bulak
89	2	24	11-02	8.4	
89	3	7	04-21	8.2	
89	3	11	03-20	8.2	
89	3	15	12-38	8.1	
89	3	22	04-29	8.0	
89	3	28	13-06	8.1	
89	3	30	09-38	8.5	
89	3	30	10-24	8.6	
89	4	5	10-47	8.0	
89	4	7	03-34	8.6	
89	4	9	03-54	8.0	
89	4	11	09-11	9.6	
89	5	20	12-32	8.0	
89	5	23	09-45	8.5	
89	6	11	07-00	10.7	
89	6	17	09-26	8.0	
89	6	19	09-58	8.2	
89	6	20	10-09	8.0	

Table 16.2

Year	Mo	Da	Time	K	Zone
89	6	20	12-18	8.5	
89	6	26	09-41	8.7	
89	6	26	23-05	9.0	
89	7	7	04-15	8.6	
89	7	9	10-31	8.6	
89	7	23	15-53	8.0	
89	7	24	05-49	8.8	
89	7	25	05-54	8.6	
89	7	30	06-29	8.7	
89	8	9	09-44	8.8	
89	8	31	10-33	8.6	
89	9	4	05-44	8.0	
89	9	14	02-29	8.1	
89	9	14	09-05	8.5	
89	9	19	06-06	8.0	
89	9	27	06-44	8.0	
89	9	28	02-07	8.8	
89	9	29	03-15	9.0	
89	9	30	23-58	8.2	
89	10	7	07-53	8.0	
89	10	23	09-14	8.4	air explosion
89	11	12	06-00	8.3	
89	11	19	09-44	9.1	
89	11	23	08-29	8.2	
89	12	7	10-59	8.5	
89	12	15	12-29	8.6	
1990	1	4	10-21	8.3	
90	1	4	11-10	8.1	
90	1	10	06-21	8.2	
90	2	6	10-03	8.1	Kotur-Bulak
90	3	2	03-54	8.0	
90	3	5	10-31	9.7	
90	3	15	13-25	8.5	
90	3	19	15-57	8.0	
90	3	20	10-18	8.0	
90	3	29	01-56	8.1	
90	4	13	01-23	8.0	
90	4	13	05-15	8.6	
90	4	13	11-29	8.6	
90	4	14	10-39	8.1	
90	4	18	07-27	8.1	
90	4	20	09-52	8.7	
90	4	22		8.7	
90	5	22		8.2	
90	5	31		8.3	
90	6	8	11-10	9.6	
90	6	12		8.4	
90	6	30		8.2	
90	7	20	15-51	8.0	
90	7	20	22-45	8.5	
90	7	29	05-40	8.0	

Table 16.2

Year	Mo	Da	Time	K	Zone
90	8	9	11-15	8.0	Kotur-Bulak
90	8	11	16-13	8.8	
90	9	3	03-42	8.0	
90	9	5	12-22	8.3	
90	9	6	02-38	8.8	
90	9	20	05-46	8.9	Kotur-Bulak
90	9	23	06-45	8.7	
90	10	2	13-34	8.3	
90	10	19	10-33	8.0	Aral
90	11	28	10-48	8.0	
90	11	30		8.0	
90	12	6	09-01	8.2	Kurty
90	12	6	10-18	8.3	
90	12	6	10-30	8.1	
90	12	10	11-26	9.5	
90	12	14	06-44	9.0	
90	12	16	06-21	8.0	
90	12	18	10-13	8.0	
90	12	23	17-05	8.0	
1991	1	3	11-58	8.1	
91	1	5	09-37	8.5	Aktuz
91	1	19	11-47	8.0	Aral
91	1	21	13-43	8.3	
91	1	23	09-32	8.4	
91	2	9	09-00	8.0	
91	3	20	11-33	8.4	
91	3	25	12-33	8.0	
91	3	28	21-09	8.4	
91	3	29	10-30	8.6	
91	3	29	22-21	8.5	
91	4	3	09-18	9.0	
91	4	12	05-06	8.1	
91	4	20	06-34	8.3	
91	4	20	11-37	8.3	
91	4	21	05-22	8.0	
91	4	28		8.1	
91	5	5	10-20	8.0	
91	5	23	06-09	8.4	
91	6	24	00-37	8.5	
91	6	28	19-14	8.4	
91	7	9	12-08	8.1	
91	7	11	06-25	8.3	
91	7	18	09-22	8.3	
91	8	1	10-15	8.6	Georg
91	8	7		8.1	
91	8	28	06-18	8.6	
91	9	20	11-00	8.5	
91	9	22	19-02	8.3	
91	9	25	05-17	8.5	
91	9	26	02-14	9.9	
91	10	12	08-14	9.4	

Table 16.2

Year	Mo	Da	Time	K	Zone
91	10	17	11-21	8.0	
91	12	10	10-13	8.6	
91	12	20	12-12	8.0	
91	12	24	10-14	8.1	
91	12	27	05-51	8.3	
1992	1	24		8.0	
92	1	30		8.5	
92	3	13		8.4	
92	3	21		9.6	
92	3	23		8.1	
92	4	2		8.2	
92	4	2		8.8	
92	4	19		8.4	
92	5	13		8.7	
92	6	1		8.1	
92	6	9		8.1	
92	6	18		8.3	
92	6	19		8.3	
92	6	25		8.0	
92	6	29		8.5	
92	7	6		8.4	
92	7	14		8.4	
92	8	5	11-40	8.2	Georg
92	9	26		8.8	
92	11	12	11-00	8.7	Georg
1993	3	5	11-56	8.5	
93	3	25	14-34	8.0	
93	3	31	05-32	8.0	
93	5	5	10-14	8.0	Georg
93	7	17	13-07	8.0	Tekely
93	9	8	07-58	8,0	
93	9	9	11-17	8.0	
93	9	19	12-30	8.1	
1994	1	8	10-29	8.5	
94	3	21	03-12	8.0	

Table 16.3. Chemical explosions in the Alma-Ata region.

Date	Time	K	Zone
3.06.72	00-01-32.5	7.9	Medeo
5.07.72	12-37-	7.1	Medeo
1.09.72	11-38-49.1	7.5	Kotur-Bulak
3.11.72	10-00-03.2	7.3	Kotur-Bulak
23.02.73	06-38-43.2	7.6	Kotur-Bulak
5.07.73	14-40-11.3	7.5	Kotur-Bulak
19.07.73	00-13-47.8	7.4	Issyk
4.08.73	08-29-52.3	7.3	Kapchagay
10.08.73	10-37-08.5	7.3	Kapchagay
3.09.73	06-22-18.3	8.7	Medeo
20.11.73	05-00-24.2	10.8	Medeo
4.12.73	10-09-28.3	7	Kotur-Bulak
18.12.73	11-05-14.5	7.7	Medeo
19.12.73	18-57-00.0	9.2	Kapchagay
30.01.74	10-42-52.8	7.2	Kotur-Bulak
5.02.74	11-14-28.9	7.3	Medeo
9.02.74	01-37-41.0	7	Medeo
19.02.74	21-25-53.6	7.6	N-W Alma-ata
22.02.74	12-29-07.5	7	Kotur-Bulak
4.03.74	11-22-54.9	7.2	Medeo
3.04.74	11-05-54.4	8.4	Medeo
24.04.74	12-01-30.4	7.1	Kotur-Bulak
26.04.74	11-26-07.5	7.4	Medeo
9.08.74	00-46-31.4	8.5	Kotur-Bulak
18.08.74	00-19-00.0	7.8	Medeo
24.08.74	00-43-19.6	7.1	Medeo
3.09.74	20-22-02.7	7.7	Kapchegay
7.09.74	07-06-34.7	7.9	Medeo
6.10.74	00-52-46.0	7.9	Medeo
30.10.74	11-57-40.2	7.4	Medeo
12.11.74	11-17-22.5	7.5	Medeo
17.11.74	08-57-40.7	8.1	Medeo
20.11.74	22-43-46.8	7.9	Kapchagay
29.11.74	07-33-48.0	8.7	Kapchagay
8.12.74	10-08-02.3	9.1	N.Alma-Ata
15.12.74	08-09-00.0	7.9	Medeo
16.12.74	10-30-00.3	9.2	N.Alma-Ata
19.12.74	11-01-25.1	7.1	Medeo
20.12.74	09-34-11.8	8.8	N.Alma-Ata
22.12.74	06-33-21.2	7.4	Medeo
27.12.74	08-52-39.5	7	Kapchagay
31.12.74	10-23-46.9	7.6	Medeo
14.01.75	11-07-04.1	7.5	Medeo
26.01.75	09-01-14.8	7.8	Medeo
2.02.75	07-52-23.4	7.8	Medeo
21.02.75	11.23.50.6	7.6	Medeo
11.03.75	11-07-45.3	7.6	Kotur-Bulak
12.03.75	08-56-15.6	7.3	Medeo
14.03.75	12-36-41.5	8	Medeo
18.03.75	01-39-20.8	9.2	Kapchagay

Table 16.3

Date	Time	K	Zone
23.03.75	08-10-51.2	8.4	Medeo
10.04.75	07-07-34.8	8	Medeo
19.04.75	13-41-13.6	7.3	Kapchagay
20.04.75	14-51-23.4	7.8	Medeo
6.05.75	11-06-35.1	7.5	Medeo
18.05.75	03-38-53.1	8.6	Medeo
8.06.75	09-56-57.0	7.9	Medeo
13.06.75	06-11-13.3	7	Medeo
14.06.75	09-52-42.3	7.7	Medeo
17.06.75	06-37-34.4	7.6	Medeo
27.06.75	07-05-44.4	7.3	Medeo
1.07.75	07-08-09.0	7	Medeo
11.07.75	20-43-09.8	8.2	Kapchagay
27.07.75	08-49-26.7	8.5	Medeo
3.08.75	08-53-21.4	7.8	Medeo
10.08.75	14-38-41.2	8.7	Medeo
17.08.75	07-12-22.0	7.5	Medeo
8.09.75	12-07-52.2	8.2	Medeo
30.10.75	18-24-16.3	7.7	N-W Alma-Ata
1.11.75	08-51-47.8	8.5	Medeo
14.11.75	09-28-56.4	7.5	Kotur-Bulak
10.12.75	09-48-18.6	7.5	Medeo
11.12.75	06-33-26.6	7.6	Medeo
22.12.75	09-45-28.1	7.5	Kotur-Bulak
10.01.76	11-42-38.3	9.3	Medeo
31.01.76	07-12-35.7	7.1	Kotur-Bulak
31.01.76	09-51-35.4	8.2	Medeo
10.02.76	05-53-11.1	7.4	Medeo
29.02.76	11-52-15.7	8.3	Medeo
26.03.76	04-34-02.0	8.3	Medeo
9.04.76	06-38-30.3	7	Medeo
21.04.76	11-20-06.7	8	Medeo
30.04.76	07-32-11.7	7.2	Medeo
30.04.76	08-42-39.1	7.4	Kotur-Bulak
7.05.76	06-52-26.2	8	Medeo
18.05.76	11-04-32.4	8	Medeo
29.05.76	10-44-42.0	7.9	Medeo
9.06.76	08-02-49.8	7.5	Medeo
11.06.76	11-19-45.5	7.2	Medeo

Table 16.4. Annual numbers of chemical explosions in Southeastern Kazakhstan during 1985 – 1994.

Year	Total	Ranges of K values 8.5-8.9	9.0-9.4	>9.4
1985	405			5
1986	371			4
1987	431			5
1988	551	14	9	2
1989	461	21	3	1
1990	489	10	2	2
1991	476	8	2	1
1992	324	2	0	1
1993	136	1	0	0
1994	89	1	0	0

Table 18.1. Mines in the Atlai-Sayan region (mines numbered 1 to 14 are in the Kusbass industrial area).

N	The name of quarry	Latitudes	Longitudes	Name of nearby town
1	Tashtagol-S	52.70-52.85	87.84-87.97	Tashtagol
2	Tashtagol-N	52.85-53.00	87.90-88.20	Tashtagol
*3	Tomusinsky, Krasnogorsky, Sibirginsky, Mezhdurechensky.	53.40-53.70	87.65-87.97	Mezhdurechensk
*4	Oldgerassky	53.70-53.95	88.05-88.25	Mezhdurechensk
*5	Osinnikovsky	53.35-53.47	87.33-87.45	
*6	Kaltansky	53.48-53.57	87.33-87.53	Kaltan
*7	Baidayevsky	53.87-54.05	87.30-87.60	
*8	Taldinsky Mshokhovsky	54.07-54.20	87.05-87.23	
*9	Kiselevsky, Krasnobrodsky Novo-Sergiyevsky, Vakhrusheva	53.90-54.25	86.33-86.64	Kiselevsk
*10	Listvyansky	53.50-53.60	86.70-86.95	Novokuznetsk
*11	Kolmogorsky-2	54.30-54.40	86.70-86.90	Belovo
*12	Kolmogorsky1-1, Kolmogorsky1-2,	54.40-54.65	86.33-86.70	Leninsk
*13	50 Years of October	54.17-54.32	86.15-86.32	Belovo
*14	Beresovsky, Chernigovsky, Kedrovsky	55.50-55.65	86.10-86.30	
15		54.60-54.75	91.00-91.35	Bellyk
16	Abakancky-1	53.55-53.80	90.80-91.50	Abakan
17	Abakansky-2	53.40-53.60	91.20-91.70	Abakan
18		54.15-54.25	93.25-93.35	Kordovo
19		51.10-51.30	90.00-90.60	Somon-Karahol
20		51.50-51.75	94.45-94.65	Kyzyl
21		51.25-51.35	91.70-91.90	Chadan
22		56.15-51.25	90.30-90.55	Nazarovo
23		53.80-53.95	92.60-93.0	Kuragin

The location of quarries, marked by star, obtained from Novosibirsk sesmological Center; another ones obtained in this study from their clustering.

Table 18.2. Large chemical explosions in the Altai-Sayan region (50-56°N, 86-96°E), during 1989-1993.

Year	Mo	Da	Ho	Mi	Sec	Lat	Long	K	N-st
					K=10				
1989	1	9	8	44	39.7	53.69	91.06	10.0	
1989	1	20	10	53	29.1	53.61	87.88	10.0	
1989	1	23	8	55	17.1	53.69	91.00	10.0	
1989	3	24	9	21	20.1	53.69	91.04	10.0	
1989	4	11	8	14	13.4	53.67	91.11	10.0	
1989	4	12	9	44	8.8	53.66	87.88	10.0	
1989	4	13	9	11	3.9	53.66	87.85	10.0	
1989	4	20	6	39	26.0	53.85	88.18	10.0	
1989	5	25	9	56	31.0	53.65	87.87	10.0	
1989	6	1	7	50	33.8	53.61	91.24	10.0	
1989	9	18	9	12	55.5	53.63	87.83	10.0	
1989	9	26	6	51	42.6	53.54	91.45	10.0	
1989	11	25	8	40	54.9	54.54	86.46	10.0	
1989	12	21	8	13	14.1	53.65	87.87	10.0	
1989	12	21	9	21	40.7	53.80	91.00	10.0	
1990	3	13	8	30	24.8	51.25	90.13	10.0	
1990	6	20	9	3	12.7	53.65	91.09	10.0	
1990	7	6	6	15	15.8	53.71	99.14	10.0	
1990	8	17	8	1	48.1	53.68	87.85	10.0	
1990	9	13	7	59	41.3	53.67	91.10	10.0	
1990	9	27	8	51	51.9	53.64	87.83	10.0	
1990	10	4	8	41	13.5	53.71	91.11	10.0	
1990	10	26	10	15	34.9	53.66	87.90	10.0	
1990	11	2	8	13	10.6	53.76	90.98	10.0	
1990	11	17	8	52	24.1	53.63	87.84	10.0	
1990	11	26	9	5	42.4	53.74	91.10	10.0	
1990	12	4	13	30	29.0	54.73	91.31	10.0	
1992	2	22	6	29	47.2	53.65	87.85	10.0	16
1992	3	20	7	47	23.0	50.40	97.70	10.0	
1992	4	3	8	9	51.3	53.70	91.15	10.0	17
1992	5	29	6	38	5.9	53.77	91.08	10.0	16
1992	5	29	6	38	13.0	52.40	92.39	10.0	
1993	1	29	8	28	13.9	53.75	91.02	10.0	
					K=9				
1989	1	6	10	24	27.0	54.10	87.10	9.0	
1989	1	6	10	24	39.1	53.65	87.87	9.0	
1989	1	10	8	22	35.3	53.95	87.52	9.0	
1989	1	16	9	21	40.1	53.69	87.97	9.0	
1989	1	17	5	7	3.2	53.99	86.48	9.0	
1989	1	18	8	46	57.0	53.91	86.57	9.0	
1989	1	19	8	50	15.7	53.71	88.07	9.0	
1989	1	19	8	52	27.6	53.60	87.74	9.0	
1989	1	20	7	37	9.0	53.51	91.44	9.0	
1989	1	20	9	1	10.3	53.58	86.88	9.0	
1989	1	24	9	6	32.9	53.62	87.85	9.0	
1989	1	24	10	11	3.5	54.20	86.49	9.0	
1989	2	1	8	40	55.6	53.73	91.06	9.0	
1989	2	1	8	46	12.6	54.17	86.51	9.0	

Table 18.2

Year	Mo	Da	Ho	Mi	Sec	Lat	Long	K	N-st
1989	2	1	9	18	26.2	53.63	87.82	9.0	
1989	2	2	9	15	34.9	53.64	87.97	9.0	
1989	2	3	8	17	54.0	53.60	91.50	9.0	
1989	2	3	8	27	7.7	53.97	86.52	9.0	
1989	2	16	9	35	49.5	53.63	87.75	9.0	
1989	2	17	9	23	34.5	53.74	91.08	9.0	
1989	2	20	9	9	57.7	53.61	87.86	9.0	
1989	2	20	10	14	21.0	55.51	86.14	9.0	
1989	2	21	11	19	30.7	53.62	87.80	9.0	
1989	2	22	9	32	19.2	53.59	87.80	9.0	
1989	2	24	10	29	.5	53.64	87.89	9.0	
1989	2	24	10	29	.5	53.64	87.89	9.0	
1989	2	25	8	3	57.7	54.16	86.47	9.0	
1989	2	27	6	57	38.5	51.71	94.49	9.0	
1989	2	27	8	3	34.0	53.86	88.13	9.0	
1989	3	1	9	46	59.8	54.09	86.56	9.0	
1989	3	3	6	42	35.9	53.91	87.40	9.0	
1989	3	3	7	46	17.1	54.15	86.46	9.0	
1989	3	3	8	49	46.1	53.71	91.12	9.0	
1989	3	3	9	23	4.5	55.48	86.15	9.0	
1989	3	6	8	57	6.1	53.54	91.50	9.0	
1989	3	7	7	25	19.0	53.70	91.00	9.0	
1989	3	9	10	42	42.1	53.62	87.79	9.0	
1989	3	10	8	59	44.5	53.69	88.07	9.0	
1989	3	10	9	34	36.4	53.62	87.81	9.0	
1989	3	11	6	37	23.5	53.11	86.55	9.0	
1989	3	14	8	42	40.1	53.55	91.45	9.0	
1989	3	15	9	7	14.9	53.96	87.50	9.0	
1989	3	15	10	10	54.8	53.66	87.94	9.0	
1989	3	15	10	17	11.2	53.52	87.44	9.0	
1989	3	15	10	40	26.3	54.27	86.19	9.0	
1989	3	21	9	27	0.0	53.86	88.15	9.0	
1989	3	22	9	9	.4	53.54	87.83	9.0	
1989	3	22	12	0	56.1	53.62	87.83	9.0	
1989	3	23	10	33	13.1	53.61	87.84	9.0	
1989	3	23	13	51	19.3	55.50	86.18	9.0	
1989	3	24	8	49	16.1	53.54	91.42	9.0	
1989	3	24	9	52	45.5	53.61	87.84	9.0	
1989	3	25	5	0	1.6	52.77	87.91	9.0	
1989	3	27	8	55	1.6	54.15	86.47	9.0	
1989	3	28	7	27	47.8	53.84	88.14	9.0	
1989	3	29	5	47	26.1	54.16	86.49	9.0	
1989	3	29	8	35	8.7	53.60	87.73	9.0	
1989	3	31	8	14	36.9	53.66	91.13	9.0	
1989	3	31	11	17	17.6	53.53	87.44	9.0	
1989	4	1	5	27	17.9	53.67	87.95	9.0	
1989	4	1	6	37	56.3	54.10	86.50	9.0	
1989	4	1	10	0	7.7	53.62	87.81	9.0	
1989	4	3	8	3	44.3	53.63	87.76	9.0	
1989	4	5	8	38	27.0	53.70	91.00	9.0	
1989	4	7	8	28	51.5	53.65	87.95	9.0	
1989	4	7	10	34	48.2	53.95	87.51	9.0	

Table 18.2

Year	Mo	Da	Ho	Mi	Sec	Lat	Long	K	N-st
1989	4	7	11	23	35.3	53.56	87.81	9.0	
1989	4	14	8	23	6.3	53.99	87.56	9.0	
1989	4	18	8	13	6.5	53.66	87.91	9.0	
1989	4	18	10	16	43.1	53.61	87.77	9.0	
1989	4	19	8	10	20.3	54.58	86.48	9.0	
1989	4	27	8	15	59.6	53.82	88.12	9.0	
1989	4	27	8	21	14.6	53.54	91.51	9.0	
1989	4	27	8	29	23.1	53.58	87.76	9.0	
1989	4	28	8	3	50.0	53.64	87.92	9.0	
1989	4	28	8	38	14.1	53.96	87.51	9.0	
1989	4	29	3	14	8.6	53.75	91.04	9.0	
1989	4	29	9	56	56.6	53.65	87.86	9.0	
1989	4	29	10	55	54.5	53.54	87.44	9.0	
1989	5	3	9	48	36.2	53.61	87.92	9.0	
1989	5	5	10	10	28.2	53.61	87.79	9.0	
1989	5	6	8	31	3.6	53.65	87.91	9.0	
1989	5	7	8	33	.8	54.55	86.47	9.0	
1989	5	7	10	31	16.9	53.95	87.46	9.0	
1989	5	10	7	38	28.3	54.01	86.54	9.0	
1989	5	11	8	37	31.4	53.58	87.75	9.0	
1989	5	12	8	51	43.4	53.61	87.75	9.0	
1989	5	16	7	48	54.2	54.14	86.44	9.0	
1989	5	16	8	10	29.1	53.61	87.91	9.0	
1989	5	17	10	58	25.6	53.62	87.85	9.0	
1989	5	19	7	16	51.0	53.99	86.55	9.0	
1989	5	21	3	2	22.3	54.46	86.43	9.0	
1989	5	25	8	22	49.0	53.62	87.89	9.0	
1989	5	26	7	32	45.1	53.53	87.42	9.0	
1989	5	26	8	26	12.3	54.18	86.45	9.0	
1989	5	26	9	3	53.0	53.95	87.51	9.0	
1989	5	27	9	24	39.6	53.63	87.84	9.0	
1989	5	31	7	33	11.5	53.85	88.15	9.0	
1989	6	1	8	24	52.8	53.56	87.69	9.0	
1989	6	2	8	24	59.7	54.17	86.51	9.0	
1989	6	2	8	31	43.2	53.63	87.74	9.0	
1989	6	5	8	39	23.4	53.72	91.05	9.0	
1989	6	6	7	16	6.7	53.81	88.20	9.0	
1989	6	6	8	29	18.5	53.59	87.83	9.0	
1989	6	8	7	47	6.3	53.68	88.10	9.0	
1989	6	8	9	25	35.6	53.59	87.76	9.0	
1989	6	9	6	43	26.8	53.47	91.52	9.0	
1989	6	9	7	0	17.9	54.16	86.46	9.0	
1989	6	9	8	5	49.5	53.60	87.77	9.0	
1989	6	9	9	47	13.9	51.19	90.58	9.0	
1989	6	9	10	42	37.4	53.53	87.42	9.0	
1989	6	14	4	59	55.2	53.66	87.89	9.0	
1989	6	15	8	21	58.8	53.65	87.86	9.0	
1989	6	15	8	48	59.6	53.63	87.89	9.0	
1989	6	20	8	45	5.3	53.61	87.70	9.0	
1989	6	23	9	10	24.5	53.63	87.82	9.0	
1989	6	24	5	8	48.4	54.00	86.47	9.0	
1989	6	24	10	35	48.9	53.95	87.46	9.0	

Table 18.2

Year	Mo	Da	Ho	Mi	Sec	Lat	Long	K	N-st
1989	6	27	4	13	52.9	53.40	87.40	9.0	
1989	6	28	7	55	9.5	53.67	88.04	9.0	
1989	6	28	8	51	39.4	53.65	87.80	9.0	
1989	6	29	7	59	48.0	53.60	87.85	9.0	
1989	6	29	8	4	47.9	54.04	86.57	9.0	
1989	6	29	10	2	10.7	53.70	88.09	9.0	
1989	7	1	8	11	21.5	53.65	87.84	9.0	
1989	7	3	7	58	8.4	54.17	86.49	9.0	
1989	7	4	7	27	41.2	53.78	88.17	9.0	
1989	7	5	10	13	50.0	53.50	91.40	9.0	
1989	7	7	6	43	18.9	54.15	86.47	9.0	
1989	7	8	9	26	57.6	53.60	87.75	9.0	
1989	7	10	9	59	22.0	53.62	87.83	9.0	
1989	7	12	8	8	33.1	53.58	87.75	9.0	
1989	7	13	9	34	2.2	53.61	87.78	9.0	
1989	7	13	10	23	6.9	53.53	87.39	9.0	
1989	7	14	7	7	36.9	53.84	88.16	9.0	
1989	7	14	7	48	47.7	55.48	86.14	9.0	
1989	7	15	9	52	25.6	53.96	87.52	9.0	
1989	7	19	4	46	56.3	53.52	91.43	9.0	
1989	7	20	9	40	26.2	53.77	91.07	9.0	
1989	7	21	8	19	13.4	53.60	87.90	9.0	
1989	7	21	8	41	42.3	53.71	87.98	9.0	
1989	7	21	8	47	51.7	54.15	86.45	9.0	
1989	7	24	8	43	7.5	53.64	91.00	9.0	
1989	7	25	8	33	27.4	54.15	86.48	9.0	
1989	7	27	8	34	54.1	54.03	86.46	9.0	
1989	7	28	8	39	51.3	53.54	87.48	9.0	
1989	8	2	8	21	10.5	53.65	91.03	9.0	
1989	8	3	7	43	16.4	53.41	87.42	9.0	
1989	8	3	8	51	53.9	53.63	87.84	9.0	
1989	8	4	6	59	38.7	53.60	91.46	9.0	
1989	8	4	7	39	44.7	54.53	86.44	9.0	
1989	8	5	7	41	22.0	54.05	86.54	9.0	
1989	8	8	8	44	41.6	53.69	87.84	9.0	
1989	8	9	7	25	56.7	53.94	87.41	9.0	
1989	8	9	8	19	24.6	53.53	87.38	9.0	
1989	8	10	7	40	44.0	53.58	91.54	9.0	
1989	8	11	9	8	52.8	53.66	87.96	9.0	
1989	8	11	10	10	48.9	53.66	87.83	9.0	
1989	8	13	4	4	38.9	52.81	87.89	9.0	
1989	8	16	6	58	47.2	54.61	86.44	9.0	
1989	8	16	7	55	57.2	54.19	86.56	9.0	
1989	8	16	8	35	44.9	53.60	87.72	9.0	
1989	8	17	8	46	2.1	53.82	88.18	9.0	
1989	8	18	10	15	54.3	54.53	86.67	9.0	
1989	8	21	8	7	54.3	53.65	87.83	9.0	
1989	8	24	7	59	48.2	53.95	87.48	9.0	
1989	8	28	8	13	19.4	53.65	87.90	9.0	
1989	8	30	8	20	18.6	53.54	87.42	9.0	
1989	8	30	9	40	31.0	53.62	87.89	9.0	
1989	8	31	7	40	32.8	54.54	86.38	9.0	

Table 18.2

Year	Mo	Da	Ho	Mi	Sec	Lat	Long	K	N-st
1989	9	4	9	57	52.4	53.96	86.48	9.0	
1989	9	5	8	53	56.9	53.59	86.74	9.0	
1989	9	7	8	7	56.2	53.80	88.12	9.0	
1989	9	7	8	55	1.7	54.14	86.46	9.0	
1989	9	8	7	27	41.3	54.10	86.40	9.0	
1989	9	8	8	25	57.8	53.68	91.07	9.0	
1989	9	8	8	54	43.4	53.87	87.74	9.0	
1989	9	9	6	45	45.5	53.62	87.90	9.0	
1989	9	12	8	33	58.8	53.59	87.78	9.0	
1989	9	14	7	52	36.6	53.95	87.46	9.0	
1989	9	15	7	33	29.2	54.12	87.13	9.0	
1989	9	22	7	31	52.2	53.61	91.43	9.0	
1989	9	23	8	19	8.9	54.15	86.42	9.0	
1989	9	25	9	45	16.8	53.60	87.72	9.0	
1989	9	26	8	54	2.5	53.58	87.91	9.0	
1989	9	28	9	11	34.6	53.68	91.12	9.0	
1989	9	29	8	34	37.9	53.95	87.41	9.0	
1989	9	29	10	2	1.7	53.39	87.40	9.0	
1989	9	30	9	31	10.2	53.64	87.80	9.0	
1989	10	2	10	0	54.1	53.52	87.43	9.0	
1989	10	4	9	27	33.6	53.70	91.03	9.0	
1989	10	4	10	7	56.1	55.52	86.15	9.0	
1989	10	5	6	34	44.2	53.63	87.77	9.0	
1989	10	6	8	43	14.9	53.89	88.13	9.0	
1989	10	6	8	48	59.3	53.62	87.86	9.0	
1989	10	12	8	47	19.4	54.20	86.40	9.0	
1989	10	12	9	45	21.5	51.62	94.60	9.0	
1989	10	12	10	19	33.9	53.60	87.82	9.0	
1989	10	13	8	4	48.0	54.58	86.43	9.0	
1989	10	13	9	6	10.2	53.67	88.01	9.0	
1989	10	13	11	0	34.0	53.62	87.91	9.0	
1989	10	17	8	17	24.7	53.95	87.53	9.0	
1989	10	18	10	59	22.5	53.62	87.78	9.0	
1989	10	19	7	53	35.3	53.86	88.17	9.0	
1989	10	20	8	59	58.2	53.81	90.91	9.0	
1989	10	20	11	8	38.2	53.54	87.44	9.0	
1989	10	26	8	25	52.5	54.53	86.42	9.0	
1989	10	26	8	49	20.9	53.55	91.49	9.0	
1989	10	31	20	49	23.8	53.44	87.31	9.0	
1989	11	3	11	55	40.7	53.65	87.88	9.0	
1989	11	4	10	10	30.0	53.64	87.85	9.0	
1989	11	11	8	51	11.6	53.61	87.79	9.0	
1989	11	11	9	35	37.8	53.52	87.41	9.0	
1989	11	13	9	19	28.7	55.53	86.20	9.0	
1989	11	14	8	38	26.2	55.53	86.17	9.0	
1989	11	14	10	26	20.7	53.59	87.72	9.0	
1989	11	15	9	19	24.4	53.47	91.38	9.0	
1989	11	16	9	54	7.7	53.38	87.39	9.0	
1989	11	20	9	16	54.1	53.60	87.69	9.0	
1989	11	20	9	48	58.2	54.02	86.48	9.0	
1989	11	21	9	59	6.8	54.49	86.39	9.0	
1989	11	25	6	4	24.5	53.95	87.49	9.0	

Table 18.2

Year	Mo	Da	Ho	Mi	Sec	Lat	Long	K	N-st
1989	11	27	9	13	31.8	53.68	91.06	9.0	
1989	11	28	8	47	40.0	53.59	87.87	9.0	
1989	11	30	8	38	13.4	53.60	87.85	9.0	
1989	12	1	8	43	6.7	53.87	87.37	9.0	
1989	12	1	9	53	39.3	53.65	87.90	9.0	
1989	12	5	8	44	41.9	53.94	87.85	9.0	
1989	12	6	7	13	21.5	54.15	86.40	9.0	
1989	12	7	9	45	23.6	54.29	86.23	9.0	
1989	12	8	8	29	56.2	54.04	86.43	9.0	
1989	12	8	8	41	6.8	53.63	87.93	9.0	
1989	12	12	7	52	38.2	53.53	91.51	9.0	
1989	12	13	8	46	33.5	54.24	86.67	9.0	
1989	12	13	9	30	40.2	53.96	87.52	9.0	
1989	12	13	10	58	47.7	53.63	87.85	9.0	
1989	12	14	10	1	51.5	53.66	87.93	9.0	
1989	12	15	8	28	54.3	53.53	87.41	9.0	
1989	12	16	9	36	.4	53.50	91.52	9.0	
1989	12	17	5	20	7.3	52.81	87.91	9.0	
1989	12	19	10	35	55.3	51.65	94.60	9.0	
1989	12	21	19	18	27.8	53.57	87.88	9.0	
1989	12	22	5	2	23.9	53.45	87.39	9.0	
1989	12	22	7	36	14.9	53.51	91.50	9.0	
1989	12	22	8	56	41.4	53.85	88.16	9.0	
1989	12	23	8	22	30.9	54.58	86.51	9.0	
1989	12	25	7	56	40.0	54.36	86.76	9.0	
1989	12	25	9	16	6.3	53.65	87.87	9.0	
1989	12	27	10	22	9.6	54.19	87.20	9.0	
1989	12	29	10	32	57.9	53.54	87.42	9.0	
1989	12	30	8	29	10.9	53.61	91.47	9.0	
1990	1	2	8	35	38.3	53.98	86.38	9.0	
1990	1	5	9	10	33.5	53.56	87.93	9.0	
1990	1	9	9	25	16.2	53.56	91.48	9.0	
1990	1	9	10	32	43.3	54.19	86.41	9.0	
1990	1	9	10	38	49.8	53.60	87.87	9.0	
1990	1	11	9	19	7.1	53.57	87.85	9.0	
1990	1	11	10	26	42.1	53.69	88.09	9.0	
1990	1	16	8	43	25.1	53.97	87.53	9.0	
1990	1	16	9	50	15.8	54.16	86.42	9.0	
1990	1	16	10	36	32.8	54.01	86.49	9.0	
1990	1	17	8	21	46.0	53.60	87.75	9.0	
1990	1	17	8	32	46.2	54.01	86.46	9.0	
1990	1	18	8	50	28.6	53.70	91.06	9.0	
1990	1	18	11	21	20.7	53.67	87.83	9.0	
1990	1	19	8	59	3.1	53.69	87.98	9.0	
1990	1	19	10	47	39.3	53.98	87.52	9.0	
1990	1	20	4	45	20.4	53.70	91.05	9.0	
1990	1	22	8	24	15.4	54.56	86.45	9.0	
1990	1	23	8	5	53.5	53.44	87.40	9.0	
1990	1	24	8	45	34.5	53.59	87.75	9.0	
1990	1	24	8	47	54.7	53.62	87.82	9.0	
1990	1	24	9	47	47.6	53.60	87.93	9.0	
1990	1	26	8	41	15.7	53.71	91.08	9.0	

Table 18.2

Year	Mo	Da	Ho	Mi	Sec	Lat	Long	K	N-st
1990	1	26	10	51	4.9	54.16	86.47	9.0	
1990	1	26	11	11	59.8	54.53	86.39	9.0	
1990	1	27	5	7	44.4	51.63	94.59	9.0	
1990	1	29	5	57	27.1	53.40	87.40	9.0	
1990	1	29	9	18	45.2	53.61	87.91	9.0	
1990	1	30	8	51	17.0	53.77	88.14	9.0	
1990	1	30	9	9	6.1	53.57	87.83	9.0	
1990	1	30	9	24	40.3	53.63	87.84	9.0	
1990	1	30	10	35	19.4	53.51	87.43	9.0	
1990	1	31	10	3	56.7	53.43	87.39	9.0	
1990	2	2	9	5	34.9	53.54	87.44	9.0	
1990	2	6	8	43	59.3	53.63	87.82	9.0	
1990	2	7	8	21	53.2	54.70	91.03	9.0	
1990	2	7	8	59	34.9	53.63	87.77	9.0	
1990	2	8	9	23	22.9	54.94	87.59	9.0	
1990	2	9	6	4	25.6	53.44	87.43	9.0	
1990	2	9	7	57	45.1	53.53	91.42	9.0	
1990	2	9	9	7	57.3	53.94	87.51	9.0	
1990	2	13	10	39	42.2	54.12	86.57	9.0	
1990	2	13	19	49	54.2	54.76	88.16	9.0	
1990	2	14	10	32	59.9	53.62	87.94	9.0	
1990	2	15	8	24	40.2	54.85	88.15	9.0	
1990	2	15	10	12	23.5	54.07	86.52	9.0	
1990	2	16	10	28	4.1	53.63	87.92	9.0	
1990	2	17	5	55	24.0	54.50	86.51	9.0	
1990	2	17	9	16	52.3	53.59	87.88	9.0	
1990	2	21	9	27	13.3	53.56	87.77	9.0	
1990	2	22	9	1	26.1	53.62	87.72	9.0	
1990	2	22	9	30	4.4	53.61	87.89	9.0	
1990	2	23	8	30	1.5	53.94	87.50	9.0	
1990	2	23	9	19	38.9	55.54	86.24	9.0	
1990	2	24	8	50	27.7	53.64	87.87	9.0	
1990	2	28	8	55	26.5	54.02	86.62	9.0	
1990	2	28	9	4	47.5	53.66	87.97	9.0	
1990	3	1	8	22	56.5	53.42	87.41	9.0	
1990	3	1	10	10	43.8	53.64	87.85	9.0	
1990	3	2	9	3	35.4	53.68	91.10	9.0	
1990	3	2	9	14	56.1	53.63	87.85	9.0	
1990	3	2	10	6	52.9	53.58	87.85	9.0	
1990	3	3	8	53	18.0	53.94	87.48	9.0	
1990	3	6	8	11	4.0	53.67	91.11	9.0	
1990	3	6	8	52	53.4	55.56	86.27	9.0	
1990	3	6	9	51	46.9	54.27	86.23	9.0	
1990	3	7	8	6	6.4	53.65	87.97	9.0	
1990	3	7	9	32	53.7	54.57	86.47	9.0	
1990	3	7	10	30	25.0	53.54	87.44	9.0	
1990	3	7	12	25	11.1	53.65	87.87	9.0	
1990	3	10	7	33	32.9	54.26	86.19	9.0	
1990	3	12	8	55	24.2	53.61	87.72	9.0	
1990	3	14	8	42	7.4	55.58	86.25	9.0	
1990	3	14	21	8	13.5	51.19	90.47	9.0	
1990	3	15	8	53	38.1	53.78	91.02	9.0	

Table 18.2

Year	Mo	Da	Ho	Mi	Sec	Lat	Long	K	N-st
1990	3	15	11	4	10.7	53.66	87.96	9.0	
1990	3	16	7	16	16.5	53.56	87.75	9.0	
1990	3	16	9	33	48.2	53.93	87.53	9.0	
1990	3	16	10	22	11.6	53.62	87.92	9.0	
1990	3	19	9	12	1.7	53.59	87.79	9.0	
1990	3	20	8	22	46.1	54.66	91.10	9.0	
1990	3	21	8	32	10.2	53.52	86.88	9.0	
1990	3	21	9	44	41.0	54.09	86.52	9.0	
1990	3	21	10	16	27.0	53.68	87.90	9.0	
1990	3	23	9	42	37.7	54.21	86.18	9.0	
1990	3	23	9	48	48.1	53.94	87.56	9.0	
1990	3	23	9	52	44.0	53.60	87.91	9.0	
1990	3	28	8	29	1.9	54.09	86.44	9.0	
1990	3	29	6	20	45.6	53.54	91.43	9.0	
1990	3	29	7	12	41.0	54.16	86.41	9.0	
1990	3	29	8	14	2.5	53.85	88.17	9.0	
1990	3	29	8	17	28.2	53.75	91.34	9.0	
1990	3	29	9	45	47.9	53.61	87.85	9.0	
1990	3	31	4	12	39.7	53.53	91.48	9.0	
1990	3	31	8	14	46.7	53.64	87.80	9.0	
1990	4	4	8	51	14.9	55.45	86.17	9.0	
1990	4	4	10	3	20.5	53.58	87.85	9.0	
1990	4	6	4	43	42.2	53.71	91.06	9.0	
1990	4	7	9	28	57.3	53.61	87.82	9.0	
1990	4	9	7	47	2.5	54.01	86.53	9.0	
1990	4	9	8	21	10.9	53.44	87.38	9.0	
1990	4	11	7	21	35.6	53.67	91.04	9.0	
1990	4	11	7	40	6.3	53.57	87.88	9.0	
1990	4	12	7	29	58.4	53.97	87.45	9.0	
1990	4	13	9	26	39.6	53.65	87.91	9.0	
1990	4	17	8	4	58.6	53.69	91.06	9.0	
1990	4	18	7	54	57.4	53.67	87.94	9.0	
1990	4	18	8	35	35.1	53.54	87.45	9.0	
1990	4	20	7	40	43.2	54.03	86.48	9.0	
1990	4	20	7	55	57.5	53.74	91.03	9.0	
1990	4	20	7	58	13.9	53.47	91.41	9.0	
1990	4	21	4	15	7.0	53.50	91.48	9.0	
1990	4	21	9	12	13.5	54.47	86.90	9.0	
1990	4	23	8	33	53.6	53.84	88.18	9.0	
1990	4	25	7	54	49.5	53.72	91.10	9.0	
1990	4	25	10	11	16.4	53.66	87.87	9.0	
1990	4	26	4	23	34.4	51.63	94.61	9.0	
1990	4	26	7	18	40.0	53.56	91.47	9.0	
1990	4	27	6	21	7.0	53.95	87.55	9.0	
1990	4	28	8	37	39.6	53.65	87.89	9.0	
1990	4	29	4	16	51.3	53.54	91.49	9.0	
1990	4	29	6	54	28.5	53.86	88.16	9.0	
1990	4	29	8	17	42.7	53.61	87.86	9.0	
1990	4	30	4	0	.5	52.79	87.90	9.0	
1990	5	7	8	17	56.3	53.68	87.95	9.0	
1990	5	8	4	10	22.6	53.93	87.37	9.0	
1990	5	8	6	43	51.8	53.68	91.05	9.0	

Table 18.2

Year	Mo	Da	Ho	Mi	Sec	Lat	Long	K	N-st
1990	5	8	7	46	18.2	53.63	87.77	9.0	
1990	5	11	6	44	59.1	53.73	91.09	9.0	
1990	5	14	7	47	8.6	53.98	86.50	9.0	
1990	5	14	7	56	29.9	53.65	87.88	9.0	
1990	5	14	10	24	30.5	53.64	87.92	9.0	
1990	5	18	8	0	34.4	53.50	87.99	9.0	
1990	5	21	7	38	5.8	53.52	87.42	9.0	
1990	5	22	9	39	24.5	53.59	87.78	9.0	
1990	5	23	6	25	58.3	54.35	86.85	9.0	
1990	5	23	7	45	24.7	53.69	91.02	9.0	
1990	5	23	9	22	2.5	53.59	87.78	9.0	
1990	5	26	9	18	42.3	53.61	87.72	9.0	
1990	5	30	6	39	54.7	53.42	87.36	9.0	
1990	5	30	8	2	5.3	53.72	91.07	9.0	
1990	5	31	5	55	52.8	54.02	86.52	9.0	
1990	5	31	7	11	57.5	54.55	86.47	9.0	
1990	5	31	8	48	51.6	53.38	87.37	9.0	
1990	5	31	8	51	44.5	54.13	87.14	9.0	
1990	6	1	5	20	24.4	53.71	91.07	9.0	
1990	6	1	8	13	56.9	53.64	87.82	9.0	
1990	6	6	6	55	33.4	53.49	91.30	9.0	
1990	6	7	7	22	7.0	53.70	91.08	9.0	
1990	6	8	7	54	41.1	53.72	91.11	9.0	
1990	6	8	9	32	4.1	53.62	87.88	9.0	
1990	6	9	4	15	17.2	53.95	87.51	9.0	
1990	6	9	7	15	39.8	54.37	86.83	9.0	
1990	6	12	6	20	10.4	53.52	91.48	9.0	
1990	6	12	6	40	46.2	54.56	86.41	9.0	
1990	6	13	8	10	26.2	53.63	91.17	9.0	
1990	6	15	8	2	37.5	53.62	87.88	9.0	
1990	6	19	7	22	52.9	53.94	87.47	9.0	
1990	6	21	8	5	58.8	53.61	87.82	9.0	
1990	6	21	8	49	12.7	53.51	91.32	9.0	
1990	6	22	6	42	59.6	53.84	88.13	9.0	
1990	6	22	8	39	23.7	53.69	91.05	9.0	
1990	6	26	8	28	13.4	54.00	86.50	9.0	
1990	6	26	12	37	17.9	51.34	91.87	9.0	
1990	6	27	6	40	18.7	53.79	90.94	9.0	
1990	6	28	8	20	45.6	53.63	87.86	9.0	
1990	7	1	5	21	57.7	54.53	86.39	9.0	
1990	7	2	7	48	30.9	53.63	87.84	9.0	
1990	7	2	8	5	56.7	53.94	87.44	9.0	
1990	7	4	4	26	18.9	53.53	91.32	9.0	
1990	7	4	8	38	38.9	54.37	86.83	9.0	
1990	7	4	9	48	24.9	53.60	87.92	9.0	
1990	7	6	4	44	40.2	53.59	87.76	9.0	
1990	7	10	8	2	39.5	54.01	86.48	9.0	
1990	7	11	6	15	52.8	53.98	87.50	9.0	
1990	7	12	7	18	17.0	53.87	88.13	9.0	
1990	7	13	4	17	28.8	53.39	87.43	9.0	
1990	7	13	5	5	11.0	53.65	91.11	9.0	
1990	7	17	3	34	18.6	53.56	91.48	9.0	

Table 18.2

Year	Mo	Da	Ho	Mi	Sec	Lat	Long	K	N-st
1990	7	18	9	10	40.3	53.65	87.94	9.0	
1990	7	19	7	46	46.8	53.57	87.90	9.0	
1990	7	25	6	18	5.8	53.74	91.04	9.0	
1990	8	1	6	47	16.3	53.64	91.05	9.0	
1990	8	1	8	31	49.7	53.59	87.74	9.0	
1990	8	2	5	48	29.6	54.16	86.53	9.0	
1990	8	2	6	53	53.1	53.93	87.49	9.0	
1990	8	3	8	3	52.4	53.60	87.83	9.0	
1990	8	6	8	33	22.9	53.98	87.45	9.0	
1990	8	8	7	59	37.6	53.65	91.06	9.0	
1990	8	9	3	11	54.3	53.90	87.35	9.0	
1990	8	9	7	17	16.3	53.57	91.52	9.0	
1990	8	9	7	20	35.6	53.81	88.15	9.0	
1990	8	11	7	48	4.5	53.69	91.03	9.0	
1990	8	14	9	37	20.1	54.16	86.52	9.0	
1990	8	15	7	21	54.6	54.54	86.50	9.0	
1990	8	15	7	41	34.3	54.00	86.51	9.0	
1990	8	20	6	39	25.7	53.62	91.38	9.0	
1990	8	21	7	58	48.5	54.07	86.59	9.0	
1990	8	22	9	10	51.0	55.63	86.25	9.0	
1990	8	23	5	54	45.0	53.68	90.99	9.0	
1990	8	24	8	6	51.5	53.59	87.72	9.0	
1990	8	24	10	16	11.2	54.52	86.44	9.0	
1990	8	28	7	29	34.4	53.60	87.80	9.0	
1990	8	29	8	7	31.2	53.66	91.09	9.0	
1990	8	30	5	20	47.9	53.83	88.18	9.0	
1990	8	31	6	39	32.0	53.57	91.46	9.0	
1990	8	31	6	58	35.5	53.72	91.05	9.0	
1990	8	31	7	7	36.7	53.98	87.53	9.0	
1990	8	31	9	12	4.9	53.63	87.85	9.0	
1990	9	1	7	26	37.1	54.15	87.22	9.0	
1990	9	4	7	30	14.9	53.65	91.11	9.0	
1990	9	6	7	47	19.7	53.71	91.08	9.0	
1990	9	6	8	30	45.5	54.02	86.50	9.0	
1990	9	7	7	30	3.8	53.70	91.03	9.0	
1990	9	7	8	7	6.9	53.61	87.77	9.0	
1990	9	10	8	3	50.2	54.01	86.50	9.0	
1990	9	13	7	44	5.3	54.02	86.56	9.0	
1990	9	14	6	49	37.2	54.01	87.54	9.0	
1990	9	14	7	30	16.6	54.12	86.52	9.0	
1990	9	17	9	46	10.5	53.50	87.46	9.0	
1990	9	19	7	11	48.8	54.19	87.14	9.0	
1990	9	19	7	43	55.6	53.61	87.71	9.0	
1990	9	19	9	10	19.1	53.63	87.89	9.0	
1990	9	20	7	32	30.7	53.91	86.55	9.0	
1990	9	24	7	42	16.1	53.59	87.93	9.0	
1990	9	25	7	57	29.5	53.67	91.08	9.0	
1990	9	25	8	55	26.6	53.59	87.75	9.0	
1990	9	26	6	43	53.0	53.84	88.12	9.0	
1990	9	26	7	26	44.8	53.52	91.50	9.0	
1990	9	26	8	4	58.8	53.56	87.79	9.0	
1990	9	26	8	29	15.1	53.53	87.38	9.0	

Table 18.2

Year	Mo	Da	Ho	Mi	Sec	Lat	Long	K	N-st
1990	9	27	4	54	10.7	53.41	87.36	9.0	
1990	9	27	8	46	28.1	54.05	86.55	9.0	
1990	9	28	7	34	38.7	53.67	91.05	9.0	
1990	9	28	8	16	1.2	53.62	87.78	9.0	
1990	9	28	8	44	13.8	53.60	87.90	9.0	
1990	10	3	9	17	17.4	53.60	87.72	9.0	
1990	10	5	5	39	35.6	53.44	87.39	9.0	
1990	10	10	8	52	1.5	54.08	86.54	9.0	
1990	10	11	8	18	24.7	53.59	87.78	9.0	
1990	10	11	10	27	42.1	53.98	86.54	9.0	
1990	10	17	7	42	15.4	53.70	91.01	9.0	
1990	10	17	9	14	35.8	53.61	87.77	9.0	
1990	10	17	9	22	34.6	53.64	87.91	9.0	
1990	10	18	8	53	49.2	53.42	87.40	9.0	
1990	10	19	5	23	2.7	54.55	86.59	9.0	
1990	10	19	7	45	40.3	53.73	91.02	9.0	
1990	10	19	8	55	1.2	53.50	87.47	9.0	
1990	10	19	11	30	33.7	54.15	86.47	9.0	
1990	10	20	9	55	27.7	53.64	87.81	9.0	
1990	10	23	8	7	45.8	53.72	91.08	9.0	
1990	10	26	7	19	26.7	53.71	91.09	9.0	
1990	10	26	8	40	16.9	53.54	91.54	9.0	
1990	10	26	9	27	43.1	53.60	87.74	9.0	
1990	10	28	5	0	.2	52.78	87.92	9.0	
1990	10	29	8	36	23.1	54.50	86.36	9.0	
1990	10	31	8	40	2.0	53.44	87.41	9.0	
1990	10	31	11	3	22.7	54.54	86.40	9.0	
1990	11	1	10	49	13.9	53.54	87.40	9.0	
1990	11	2	8	56	28.0	53.58	87.83	9.0	
1990	11	6	6	17	26.0	53.53	91.43	9.0	
1990	11	6	6	49	52.7	53.77	91.06	9.0	
1990	11	6	9	28	34.0	53.83	88.13	9.0	
1990	11	12	9	24	43.8	51.13	90.07	9.0	
1990	11	16	5	52	8.4	54.16	86.41	9.0	
1990	11	16	9	19	34.4	54.72	86.32	9.0	
1990	11	16	10	13	3.1	54.08	86.49	9.0	
1990	11	20	8	39	1.0	53.53	91.48	9.0	
1990	11	21	8	36	13.2	53.55	91.44	9.0	
1990	11	22	9	46	1.5	54.01	86.55	9.0	
1990	11	27	9	20	40.0	54.18	86.46	9.0	
1990	11	29	8	21	20.9	53.78	91.13	9.0	
1990	11	29	9	34	54.1	53.60	87.70	9.0	
1990	12	4	6	21	57.5	54.11	87.17	9.0	
1990	12	4	9	30	32.8	53.55	87.50	9.0	
1990	12	5	9	0	3.9	53.85	88.13	9.0	
1990	12	5	9	2	13.9	54.20	86.48	9.0	
1990	12	5	9	48	23.6	53.66	87.90	9.0	
1990	12	6	8	24	16.1	53.57	91.42	9.0	
1990	12	7	9	19	26.6	53.97	87.49	9.0	
1990	12	7	11	25	27.3	53.63	87.88	9.0	
1990	12	12	8	27	20.2	53.50	91.47	9.0	
1990	12	12	9	4	6.7	54.02	86.55	9.0	

Table 18.2

Year	Mo	Da	Ho	Mi	Sec	Lat.	Long	K	N-st
1990	12	13	8	18	43.9	53.75	91.07	9.0	
1990	12	18	8	33	11.1	54.10	87.09	9.0	
1990	12	18	10	8	39.0	53.89	87.89	9.0	
1990	12	19	7	31	.8	54.65	86.65	9.0	
1990	12	19	8	2	33.0	57.10	88.30	9.0	
1990	12	20	7	47	48.5	53.56	91.29	9.0	
1990	12	20	10	2	13.8	53.71	87.86	9.0	
1990	12	20	10	23	42.7	53.59	87.75	9.0	
1990	12	21	11	22	57.4	53.53	87.47	9.0	
1990	12	24	8	15	6.7	53.55	91.48	9.0	
1990	12	27	4	55	2.0	53.60	87.77	9.0	
1990	12	27	8	16	40.9	53.52	87.50	9.0	
1990	12	27	8	56	4.5	51.30	91.87	9.0	
1990	12	28	6	8	50.1	53.54	91.43	9.0	
1990	12	28	8	0	46.9	53.98	87.56	9.0	
1990	12	29	7	29	7.6	53.76	91.15	9.0	
1991	7	26	9	14	21.0	53.70	91.13	9.0	
1991	8	11	15	13	32.0	52.59	90.15	9.0	
1991	8	13	8	48	5.0	53.71	91.10	9.0	
1991	8	15	8	27	20.0	53.69	90.98	9.0	
1991	8	26	10	15	39.0	53.54	91.46	9.0	
1991	10	17	9	20	25.0	53.77	91.08	9.0	
1991	10	18	4	5	35.0	53.57	91.42	9.0	
1991	10	23	10	0	26.0	53.76	91.08	9.0	
1991	11	1	9	59	44.0	53.79	91.05	9.0	
1991	11	11	9	26	55.0	53.82	91.14	9.0	
1991	12	18	7	15	8.0	53.68	91.10	9.0	
1992	1	18	6	40	37.5	51.71	94.60	9.0	15
1992	2	18	9	36	10.0	53.56	87.90	9.0	15
1992	2	19	8	9	5.7	53.74	91.03	9.0	14
1992	2	26	4	45	14.2	53.36	87.41	9.0	16
1992	2	28	3	47	36.2	53.58	91.50	9.0	17
1992	2	28	7	1	6.1	53.88	87.58	9.0	16
1992	3	2	9	3	16.6	54.54	86.36	9.0	17
1992	3	3	8	36	26.3	53.57	87.87	9.0	17
1992	3	5	7	58	8.1	53.82	88.16	9.0	15
1992	3	7	4	59	29.0	53.70	91.04	9.0	16
1992	3	11	7	59	32.4	53.56	91.44	9.0	17
1992	3	11	8	22	33.4	53.86	88.14	9.0	17
1992	3	12	8	11	54.0	53.65	91.10	9.0	17
1992	3	14	12	58	43.4	54.87	89.71	9.0	17
1992	3	17	8	24	47.4	53.72	91.13	9.0	17
1992	3	19	8	31	.3	54.06	86.59	9.0	15
1992	3	20	7	48	19.9	53.79	90.98	9.0	15
1992	3	23	10	22	49.8	53.53	87.43	9.0	16
1992	3	24	7	27	19.7	53.79	91.08	9.0	17
1992	3	24	8	48	23.9	53.57	91.43	9.0	17
1992	3	25	11	25	13.5	54.08	86.52	9.0	17
1992	3	27	7	31	41.0	53.73	91.09	9.0	14
1992	3	27	9	53	26.3	53.59	87.85	9.0	16
1992	3	28	7	31	45.5	54.46	86.38	9.0	16
1992	4	1	8	14	1.7	53.64	87.79	9.0	17

Table 18.2

Year	Mo	Da	Ho	Mi	Sec	Lat	Long	K	N-st
1992	4	3	8	16	55.0	51.18	90.59	9.0	16
1992	4	10	8	36	5.7	54.05	86.43	9.0	13
1992	4	22	4	43	30.1	53.55	91.45	9.0	17
1992	4	28	4	34	19.6	53.59	91.39	9.0	16
1992	5	6	8	53	49.0	53.59	91.42	9.0	17
1992	5	7	9	2	1.0	53.62	87.88	9.0	17
1992	5	12	7	16	21.9	53.58	91.47	9.0	16
1992	5	13	6	27	23.7	53.73	91.15	9.0	16
1992	5	25	8	34	30.3	53.64	87.79	9.0	17
1992	6	3	8	26	42.0	53.55	91.48	9.0	
1992	6	4	7	43	28.7	53.75	91.05	9.0	15
1992	6	11	6	45	13.5	53.78	91.06	9.0	16
1992	6	17	8	30	8.1	53.60	91.38	9.0	16
1992	6	18	7	33	26.5	53.78	91.05	9.0	15
1992	6	23	7	42	33.6	54.16	87.25	9.0	16
1992	6	30	4	35	30.2	53.43	87.39	9.0	16
1992	7	24	8	9	30.7	53.78	91.06	9.0	14
1992	7	24	9	49	55.0	53.58	91.40	9.0	12
1992	8	3	7	31	23.4	53.58	91.54	9.0	13
1992	8	5	4	26	26.1	53.87	87.52	9.0	13
1992	8	14	7	38	55.3	53.70	91.11	9.0	17
1992	8	15	7	11	42.6	54.11	86.51	9.0	15
1992	8	21	9	22	16.0	53.57	87.96	9.0	16
1992	8	22	22	25	46.9	52.23	88.74	9.0	16
1992	8	26	8	19	47.5	53.63	91.46	9.0	16
1992	8	28	4	32	12.7	53.80	91.03	9.0	13
1992	8	31	11	46	10.9	52.79	87.94	9.0	14
1993	1	6	8	23	7.6	53.83	88.16	9.0	
1993	1	15	8	52	33.0	53.70	87.90	9.0	
1993	1	28	7	11	54.6	53.43	87.39	9.0	
1993	1	29	3	55	9.7	53.96	87.57	9.0	
1993	1	31	15	27	58.7	50.56	90.24	9.0	
1993	2	1	8	53	6.1	53.56	91.49	9.0	
1993	2	3	8	51	1.2	53.53	87.48	9.0	
1993	2	6	6	36	32.9	53.72	91.03	9.0	
1993	2	10	8	43	14.5	53.68	87.96	9.0	
1993	2	10	8	47	34.3	53.70	91.10	9.0	
1993	2	11	5	11	38.6	54.37	86.89	9.0	
1993	2	19	7	8	51.1	53.60	91.44	9.0	
1993	2	22	8	27	36.9	53.59	87.95	9.0	
1993	2	26	6	56	31.9	53.53	87.37	9.0	
1993	2	27	4	54	17.0	54.00	87.60	9.0	
1993	2	28	3	1	25.8	53.68	91.07	9.0	
1993	3	3	7	2	45.7	53.75	91.05	9.0	
1993	4	2	9	16	19.9	53.70	91.06	9.0	
1993	5	8	6	3	46.6	53.59	91.38	9.0	15
1993	5	14	6	47	48.2	54.04	87.44	9.0	16
1993	5	18	7	5	47.1	53.83	88.23	9.0	14
1993	5	18	9	39	42.4	53.58	87.83	9.0	13
1993	5	19	6	29	40.1	53.73	91.02	9.0	14
1993	5	27	7	4	3.3	53.61	87.83	9.0	14
1993	5	27	8	32	37.4	53.64	87.88	9.0	14

Table 18.2

Year	Mo	Da	Ho	Mi	Sec	Lat	Long	K	N-st
1993	5	28	5	31	35.0	54.59	86.50	9.0	14
1993	6	3	6	21	29.7	54.20	87.27	9.0	14
1993	6	3	7	47	36.8	53.85	88.19	9.0	14
1993	6	4	8	35	14.8	53.59	91.39	9.0	14
1993	6	11	9	7	49.8	53.65	87.81	9.0	15
1993	6	18	7	59	42.2	53.70	91.07	9.0	15
1993	6	18	9	17	25.5	54.12	86.54	9.0	15
1993	6	28	9	43	14.8	53.75	91.07	9.0	15
1993	6	29	8	5	48.1	54.53	86.42	9.0	13
1993	6	30	6	9	2.0	54.52	86.43	9.0	14
1993	7	2	7	48	18.0	53.75	91.05	9.0	14
1993	7	6	7	27	8.4	53.76	91.04	9.0	15
1993	7	8	8	7	55.2	53.59	91.40	9.0	14
1993	7	12	7	33	35.8	53.66	88.02	9.0	16
1993	7	14	4	28	59.7	53.95	87.59	9.0	15
1993	7	16	8	53	6.1	53.73	91.09	9.0	14
1993	7	29	7	27	31.6	53.60	87.75	9.0	13
1993	8	2	9	32	20.8	53.66	87.92	9.0	11

Table 18.3. Chemical explosions with K > 8, recorded by the Cheremushki seismographic station, July 1991 - May 1993.

Year	Mo	Da	Ho	Mi	S-P	K
		1991				
1991	7	26	9	14	13.0	9.2
1991	8	2	5	4	10.5	8.2
1991	8	8	8	52	10.5	9.1
1991	8	9	8	37	13.0	8.4
1991	8	13	5	37	10.0	8.1
1991	8	16	5	44	11.0	8.2
1991	8	29	8	42	13.5	9.1
1991	9	9	9	35	11.5	8.5
1991	9	11	8	26	12.5	9.5
1991	9	12	8	42	12.5	9.4
1991	9	13	10	55	10.5	9.2
1991	9	15	7	50		9.6
1991	9	25	6	36	14.8	9.8
1991	9	26	8	46	12.5	9.5
1991	9	27	8	9	13.0	8.4
1991	9	30	10	34	11.0	8.3
1991	10	4	8	57	9.0	8.5
1991	10	11	9	24	13.0	9.0
1991	10	14	10	9	11.0	9.3
1991	10	24	9	30	10.5	8.3
1991	10	25	7	58	13.0	9.1
1991	10	28	9	48	12.0	8.9
1991	10	29	11	43	12.5	8.0
1991	10	31	9	26	13.0	9.5
1991	11	6	8	51	12.0	8.8
1991	11	14	9	28	13.0	8.1
1991	11	15	6	22	9.5	9.0
1991	11	20	9	22	10.0	8.6
1991	11	26	9	39	11.0	8.2
1991	11	27	8	50	13.0	9.5
1991	12	2	8	20	11.0	8.0
1991	12	7	5	35	14.0	8.3
1991	12	12	8	48	13.0	8.5
1991	12	13	9	40	10.5	9.8
1991	12	16	9	39	13.0	8.1
1991	12	19	10	6	6.5	8.0
1991	12	20	8	35	12.5	9.4
1991	12	27	17	26	11.0	8.5
1991	12	27	21	35	11.0	8.9
		1992				
1992	1	4	9	57	13.0	9.5
1992	1	14	9	11	13.5	8.4
1992	1	16	9	38	11.0	9.4
1992	1	22	2	23	3.0	8.1
1992	1	22	7	59	9.5	8.9
1992	2	6	5	0	10.5	8.5

Table 18.3

Year	Mo	Da	Ho	Mi	S-P	K
1992	2	8	7	50	13.0	8.5
1992	2	8	9	13	15.0	8.0
1992	2	20	8	5	10.5	8.2
1992	2	24	8	54	13.5	9.5
1992	2	25	8	11	13.0	8.1
1992	2	28	3	47	11.0	9.2
1992	2	28	8	26	12.5	8.9
1992	3	6	8	36	11.0	8.0
1992	3	12	8	12	13.0	9.7
1992	3	13	4	49	9.0	8.2
1992	3	22	9	44	11.0	9.0
1992	3	27	8	14	11.0	8.9
1992	3	31	5	35	11.5	8.0
1992	4	1	4	43	11.0	8.4
1992	4	3	4	15	11.5	8.6
1992	4	3	8	10	12.5	10.1
1992	4	22	7	6	12.5	8.1
1992	4	24	6	39	13.0	8.9
1992	4	30	6	30	13.5	8.7
1992	5	8	5	59	13.5	8.9
1992	5	18	8	57	11.0	8.6
1992	5	20	6	45	11.0	8.2
1992	5	20	8	20	13.0	9.0
1992	5	27	4	17	12.5	8.0
1992	5	29	6	38	13.0	9.7
1992	6	5	8	2	11.0	8.3
1992	6	9	6	15	13.0	9.2
1992	6	11	18	23	10.0	8.5
1992	6	23	6	40	13.5	8.6
1992	6	29	7	49	12.0	8.0
1992	7	2	7	35	10.5	9.0
1992	7	8	5	38	12.5	10.2
1992	7	10	3	48	11.5	8.9
1992	7	13	5	22	12.5	8.3
1992	7	14	7	58	10.5	8.4
1992	7	15	8	44	13.0	8.3
1992	7	17	6	38	12.5	8.7
1992	7	22	21	23	14.5	8.4
1992	8	7	6	32	10.5	8.5
1992	8	7	10	28	12.5	8.5
1992	8	12	8	12	11.0	8.9
1992	8	14	7	49	12.0	9.3
1992	8	21	8	9	13.0	8.3
1992	9	11	7	48	10.0	8.5
1992	9	15	5	38	15.0	9.3
1992	9	25	6	37	4.0	8.9
1992	10	5	9	46	11.0	8.2
1992	10	6	9	25	12.0	9.0
1992	10	7	7	59	13.0	8.0
1992	10	8	8	35	13.0	9.5
1992	10	8	8	35	13.5	8.4
1992	10	9	10	14	12.0	9.3

Table 18.3

Year	Mo	Da	Ho	Mi	S-P	K
1992	10	13	7	31	12.5	8.8
1992	10	19	8	19	11.0	8.7
1992	10	19	9	10	13.0	9.9
1992	10	22	8	35	13.0	9.2
1992	10	27	7	58	13.0	9.5
1992	10	28	4	49	11.0	8.5
1992	10	28	6	47	13.0	8.9
1992	10	29	8	39	12.0	8.2
1992	11	4	7	48	10.0	8.9
1992	11	6	8	11	13.5	9.2
1992	11	6	8	20	10.5	8.5
1992	11	7	16	28	11.5	8.0
1992	11	11	8	30	13.0	9.3
1992	11	13	6	43	10.5	9.9
1992	11	17	10	19	13.0	9.0
1992	11	20	7	7	13.0	9.2
1992	11	26	7	24	13.5	9.7
1992	11	27	8	29	13.5	8.0
1992	12	1	6	51	13.0	8.9
1992	12	1	7	0	10.5	8.3
1992	12	1	8	29	13.0	8.9
1992	12	4	7	55	10.0	9.7
1992	12	8	7	8	13.0	9.3
1992	12	10	7	30	11.0	10.1
1992	12	11	6	48	13.0	9.1
1992	12	11	8	44	12.0	8.3
1992	12	12	12	18	12.0	8.8
1992	12	16	8	25	12.5	8.8
1992	12	16	10	23	12.5	8.4
1992	12	17	5	24	12.0	8.3
1992	12	18	8	47	12.5	8.7
1992	12	18	8	58	10.5	9.1
1992	12	21	8	48	12.5	8.3
1992	12	24	9	22	12.5	8.4
1992	12	25	8	13	13.0	9.7
		1993				
1993	1	11	8	37	13.5	9.9
1993	1	16	4	10	13.0	8.2
1993	1	18	8	39	10.5	9.4
1993	1	19	9	34	13.0	8.9
1993	1	27	4	16	14.0	8.0
1993	1	28	5	38	12.0	8.3
1993	1	29	8	28	13.5	10.5
1993	1	30	10	56	12.0	9.1
1993	2	1	7	55	13.0	8.6
1993	2	1	8	53	11.0	9.9
1993	2	3	9	53	11.0	9.0
1993	2	5	9	5	10.5	9.1
1993	2	6	8	17	15.0	8.0
1993	2	12	8	51	11.5	8.9
1993	2	15	8	45	13.0	8.1
1993	2	17	5	53	11.0	8.8

Table 18.3

Year	Mo	Da	Ho	Mi	S-P	K
1993	2	17	8	3	13.0	8.6
1993	2	23	7	51	13.0	8.0
1993	2	23	9	5	11.0	8.9
1993	3	3	7	24	10.5	9.0
1993	3	5	6	21	13.0	9.4
1993	3	5	9	8	10.5	9.2
1993	3	9	8	51	12.0	8.2
1993	3	10	5	57	10.0	8.5
1993	3	12	6	53	10.0	9.2
1993	3	16	6	31	1.0	8.2
1993	3	17	8	36	13.0	9.9
1993	3	19	5	22	10.5	9.4
1993	3	19	7	41	13.0	9.1
1993	3	23	7	30	10.0	8.0
1993	3	24	8	18	13.0	9.2
1993	3	25	0	29	12.0	8.6
1993	3	26	6	41	10.0	9.9
1993	3	26	9	48	13.0	9.0
1993	3	30	6	20	12.5	9.1
1993	4	2	6	10	11.0	9.2
1993	4	6	5	49	1.5	8.0
1993	4	6	6	39	12.0	9.0
1993	4	9	3	29	10.5	8.5
1993	4	14	8	18	10.5	9.3
1993	4	15	5	46	12.5	8.5
1993	4	16	6	12	11.0	9.1
1993	4	20	7	38	11.0	9.6
1993	4	23	7	3	10.5	8.8
1993	4	23	8	9	13.0	8.1
1993	4	24	5	5	13.0	9.1
1993	4	30	7	16	13.0	8.9
1993	5	7	6	43	12.5	8.9
1993	5	15	5	46	12.5	8.5
1993	5	23	5	44	11.0	8.1
1993	5	24	7	38	13.0	9.1
1993	5	26	7	30	13.0	8.5
1993	5	28	6	57	12.0	8.0

Table 18.4. Distribution of seismic activity with different K values, for different Kuzbass mines, 1989-1992.

N	The number of determined events									
quarry	Total	K=10	K=9	K=8	K=7	K=6	1989	1990	1991	1992
1	17	-	5	3	8	1	4	13	-	-
2	29	-	-	2	11	15	9	20	-	-
3	207	10	169	27	1	-	110	97	-	-
4	28	1	24	2	-	1	17	11	-	-
5	30	-	18	12	-	-	21	9	-	-
6	31	-	26	5	-	-	17	14	-	-
7	43	-	38	4	-	-	21	22	-	-
8	11	-	8	3	-	-	4	7	-	-
9	99	-	71	26	2	-	45	54	-	-
10	5	-	3	2	-	-	3	2	-	-
11	6	-	4	2	-	-	2	4	-	-
12	32	-	23	7	-	1	16	16	-	-
13	9	-	5	3	1	-	4	5	-	-
14	9	-	8	1	-	-	5	4	-	-
15	3	1	2	-	-	-	-	3	-	-
16	102	11	84	6	-	1	31	60	8	3
17	51	1	45	4	-	-1	21	26	2	2
18	2	-	-	2	-	-	1	1	-	-
19	8	1	3	-	-	3	1	7	-	-
20	7	-	5	1	1	-	3	4	-	-
21	1	1	-	-	-	-	-	-	-	1
22	1	1	-	-	-	-	-	-	-	1
23	1	-	1	-	-	-	-	-	1	-
24	1	-	-	-	1	-	-	-	1	-

Table 18.5. Seismographic stations in the Altai-Sayan region and surrounding areas, operating as of October 1996.

#	Code	Name	Owner	Lat	Long
1	TDK	Taldy-Kurgan	Kazakhstan	45.00	78.40
2.	KAR	Kapa-Arasan	Kazahkstan	45.29	79.35
3,	NOV	Novosibirsk	Altay-Sayan	54.90	83.30
4.	ZSN	Zaysan	Kazakhstan	47.45	84.40
5.	USK	Ust-Kan	Altay-Sayan	50.60	84.77
6.	ELT	Yeltsovka	-"-	53.25	86.27
7.	ART	Artybash	-"-	51.80	87.30
8.	ATS	Aktash	-"-	50	88
9.	TEL	Tehely	-"-	51.00	90.20
10.	VEN	Verkh-basa	-"-	53.30	90.30
11.	CHE	Cheremushki	-"-	52.77	91.47
12.	JOI	Joy	-"-	53	91.5
13.	MIN	Mina	-"-	55.03	92.92
14.	ARD	Aradan	-"-	51	93
15.	ERN	Erzin	-"-	50.25	95.17
16.	ORL	Orlik	Baikal	52.50	99.80
17.	MOY	Mondy	Baikal	51.68	100.98

Table 19.1. Mines/quarries in the Baikal region
G – from Gonenetsky's list of quarries
D – from Delitsin's bulletin.

No/Name	Lat	Long	Source
Abagatuy	49.6	117.9	G
Aginskoye	51.05	114.7	G D
Airgun			D
Akatuy	51.0	117.7	G
Alar			D
Angasolka			D
Antipikha	52.0	113.5	G D
Atamanovka	51.85	113.65	G
Atyka	50.95	116.8	G
Azei			D
Balyaga	51.2	108.9	G D
Baldgickan	49.3	110.5	G
Baley	51.55	116.5	G D
Balyra	49.7	111.7	G
BayanGol	50.75	103.4	G D
Bodaiboh	57.8 ?	114.0	D
Bom Gorkhon	51.35	109.4	G
Borshovochny			D
Bouroshina			D
Cheremkhovsky	53.22	103.1	G D
Chernovsky kopy	52	113.2	G D
Chitah			D
Darkhan	49.1	106.3	G
Davendah	53.6	119.4	G D
Dinamitny			D
Djida			D
Drovyanaya	51.6	113.1	G D
Erdenet	48.95	104.1	G D
Gousinka	51.2	106.4	G D
Gorhon			D
Gorny Zerentuy	51.25	119.6	G
Igirmah	57.15	103.9	G D
Ilim	56.4	104.25	G D
Inkurgue			D
Kadaya	51	119.1	G
Kalanguy	50.95	116.5	G D
Karymskoye	51.6	114.3	G D
Kharanoot	52.85	105	G D
Kharanour	50.1	116.6	G D
Klichka	50.35	118	G
Kloochevsky	53.6	119.5	G D
Krasnokamensk	50.05	118.1	G
Makar			D
Medvedchikova Pad	51.75	107.6	G D
Medvedevka			D
Menza	49.5	108.9	G
Mondy			D
Mugun			D
Novopavlovka	51.2	109.2	G D
Novy Doorookhtooi	50.35	114.4	G
Olovyannaya	50.95	115.65	G D
Orlenok			D
Pereval			D
Pervomaisky	51.65	115.7	G D
Rudnogorsk	57.3	103.7	G D
S-z.Cheremkhovo	53.8	102.7	G D
Safronovo			D
Sangino	50:65.	103.7	G D
Sayany			D
Sharyn-gol			D
Sherlovaya Gora	50.45	116.25	G D
Sludyansky	51.65	103.6	G D
Solnechny	51.5	118.9	G
Tarakanovka	51.95	106.5	G D
Tatarsky klooch	51.6	108.4	G D
TNL			D
Tologoi	51.9	110	G
Tsaganur			D
Tulunsky	54.6	100.5	G D
Vakhmistrovo	51.75	107.5	G D
Vershina	51.3	117.8	G
Voznesenka	51.7	109.55	G D
Zaigrayevo			D
Zakamensk			D
Zalarinsky			D
Zapokrovsky	50.75	119.2	G

Table 19.2. Chemical explosions of known blast size (Q), recorded in the Baikal region, Jul 1 – Oct 3 1991 and Jun 1 – Oct 2 1992 (from the catalog of L. Delitsin — personal communication).

Year	Mo	Da	Ho	Mi	Quarry	Q tons
1992	6	22	7	8	Azey	128
1992	7	10	7	10	Azey	71
1992	8	5	6	10	Azey	78
1992	8	21	8	25	Azey	100
1992	8	26	8	3	Azey	73
1992	9	8	7	30	Azey	79
1992	9	19	6	53	Azey	122
1991	7	24	8	5	Cheremkhovo	103
1991	7	30	7	25	Cheremkhovo	91
1991	8	1	6	5	Cheremkhovo	88
1991	8	12	8	20	Cheremkhovo	112
1991	8	15	6	10	Cheremkhovo	112
1991	8	27	7	10	Cheremkhovo	103
1991	9	3	4	0	Cheremkhovo	90
1991	9	11	6	55	Cheremkhovo	108
1991	9	13	3	0	Cheremkhovo	77
1992	6	11	5	35	Cheremkhovo	75
1992	6	17	4	55	Cheremkhovo	88
1992	6	18	5	33	Cheremkhovo	73
1992	6	19	8	0	Cheremkhovo	78
1992	6	30	5	5	Cheremkhovo	92
1992	7	21	4	45	Cheremkhovo	105
1992	7	24	4	16	Cheremkhovo	105
1992	8	14	4	30	Cheremkhovo	75
1992	9	2	6	50	Cheremkhovo	89
1992	7	9			Gousinka	113
1991	7	24	5	0	Safronovo	193
1991	7	30	7	30	Safronovo	139
1991	8	6	7	30	Safronovo	95
1991	8	9	7	40	Safronovo	106
1991	8	13	7	15	Safronovo	89
1991	8	16	6	10	Safronovo	81
1991	8	22	8	10	Safronovo	165
1991	8	28	7	30	Safronovo	148
1991	9	3	7	15	Safronovo	93
1991	9	5	6	10	Safronovo	78
1991	9	17	7	0	Safronovo	152
1991	9	20	7	0	Safronovo	93
1991	9	24	9	30	Safronovo	83
1991	9	26	7	10	Safronovo	109
1992	6	17	5	30	Safronovo	99
1992	6	19	5	30	Safronovo	146
1992	6	24	6	40	Safronovo	113
1992	7	7	6	50	Safronovo	184
1992	7	10	7	0	Safronovo	154
1992	7	13	6	0	Safronovo	71
1992	7	17	6	36	Safronovo	71
1992	7	21	5	15	Safronovo	100
1992	8	4	7	30	Safronovo	78
1992	8	6	5	30	Safronovo	129
1992	8	11	6	30	Safronovo	139
1992	8	12	7	15	Safronovo	74
1992	8	20	4	30	Safronovo	80
1992	9	29	5	45	Safronovo	79

Table 19.3. Numbers of blasts during 1991 and 1992 at different Baikal mines/quarries.

Quarry	The number of blasts 1991	1992	Total
Agin	1	0	1
Airgun	0	8	8
Alar	0	6	6
Angas	0	1	1
Antipikha	1	0	1
Azey	0	49	49
Baley	1	1	2
Balyaga	2	3	5
BayanGol	0	2	2
Bodaybo	4	1	5
Borshovochny	1	4	5
Burovshina	5	10	15
Cheremkhovo	89	62	151
Chernovskie kop	1	0	1
Chita	0	1	1
Darkhan	11	4	15
Davenda	14	2	16
Drovyanaya	3	3	6
Dynamitny	1	1	2
Erdenet	2	1	3
Gorkhon	0	5	5
Goosinka	24	66	90
Igirma	1	0	1
Ilim	10	0	10
Inkurguy	2	6	8
Kalanguy	1	0	1
Karymskoye	1	1	2
Kharanor	0	3	3
Kharanut	3	1	4
Klyuchevsky	2	1	3
Makar	0	7	7
Medvedchikova p	2	0	2
Mondy	1	0	1
Mugun	0	8	8
NovoPavlovka	1	7	8
Olovyannaya	6	0	6
Orlenok	3	4	7
Pereval	5	4	9
Pervomaisky	2	1	3
Rudnogorsk	1	1	2
S-z Cheremkhovo	0	4	4
Safronovo	33	45	78
Sangino	9	12	21
Sayany	0	1	1
SharynGol	0	27	27
Sherlovaya gora	6	0	6
Sludyanka	16	4	20
TNL	1	0	1
Tarakanovka	3	8	11
Tatarsky	5	7	12
Tsagan	0	14	14
Tulun	82	71	153
Vakhmistrovo	0	3	3
Voznesenka	3	0	3
Zaigraevo	0	3	3
Zakamensk	7	0	7
Zalar	0	3	3

Table 19.4. The distribution of charge sizes (Q), of blasts at different mines/quarries in the Baikal region.

Quarry	The number of events with various Q values						
	Total	Unknown	Q <10	10-20	20-50	50-100	Q>100
Tulun	153	109	15	17	12		
Cheremkhovo	151	76	4	7	34	23	7
Gousinka	97	90	2		3	1	1
Safronovo	58	1	10	12	14	28	13
Azey	49	1	3	8	16	18	3
SharynGol	26	26					
Sludyanka	21	21					
Sangino	21	11	9	1			
Davenda	16	16					
Burovshina	15	10	5				
Darkhan	15	15					
Tsagan	13	1	5	2	3	2	
Tatarsky	13	7	2	3	1		
Tarakanovka	11	8		1	2		
Ilim	10	10					
Pereval	9	7		1	1		
Airgun	8	8					
NovoPavlovka	8	8					
Mugun	8		3	5			
Orlenok	7	3	4				
Inkurguy	7	3		1	2	2	
Makar	7	7					
Sherlovaya gora	6	6					
Zakamensk	6	6					
Olovyannaya	6	6					
Drovyanaya	6	6					
Alar	6	1	1	1	3		
Balyaga	5	5					
Bodaybo	5	5					
Gorkhon	5	4		1			
S-z Cheremkhovo	4	4					
Kharanut	4	3	1				
Borshovochny	4	4					
Voznesenka	3	3					
Pervomaysky	3	3					
Kharanor	3	3					
Klyuchevsky	3	3					
Erdenet	3	3					
Vakhmistrovo	3		3				
Zaigraevo	3	1	2				
Zalar	3	1	1		1		
Karymskoye	2	2					
Medvedchikova p	2	2					
Rudnogorsk	2	2					
Baley	2	2					
BayanGol	2	2					
Dynamitny	2		1	1			
Agin	1	1					
Angas	1			1			
Antipikha	1	1					
Chernovskie kopy	1	1					
Chita	1	1					
Dzhida	1	1					
Igirma	1	1					
Kalanguy	1	1					
Mondy	1	1					
Sayany	1	1					
TNL	1	1					
Total		526	71	62	92	74	24

Table 19.5. Seismic events included in the ESSN catalog as earthquakes for the Baikal regions, that are probably chemical explosions.

Q	Year	Mo	Da	Ho	Mi	Sec	Latit	Longit	K
E	1962	2	9	19	41	2.0	51.60	109.30	9.0
A	1962	2	23	9	10	14.0	51.80	106.70	9.0
B	1962	3	2	8	7	31.0	51.20	106.80	9.0
A	1962	3	26	9	32	14.0	51.90	106.80	9.0
F	1962	4	20	6	48	4.0	51.90	113.40	7.0
A	1962	5	6	12	57	20.0	51.90	106.50	9.0
B	1962	6	6	8	24	16.0	51.30	106.70	9.0
F	1962	7	17	6	30	2.0	51.90	113.40	7.0
A	1962	8	14	2	10	42.0	51.60	106.90	9.0
A	1962	8	23	9	4	51.0	51.60	106.60	9.0
A	1962	11	16	8	36	57.0	51.90	106.60	9.0
B	1962	12	29	7	46	58.0	51.20	106.60	9.0
E	1963	3	22	9	41	10.0	51.50	109.70	9.0
A	1963	4	10	2	27	40.0	51.70	106.20	9.0
F	1963	12	26	7	58	55.0	51.80	113.40	7.0
D	1964	2	14	10	28	42.0	51.80	115.50	7.0
F	1964	2	28	7	29	43.0	51.90	113.30	7.0
A	1964	3	18	8	48	52.0	51.90	106.70	9.0
F	1964	4	16	9	38	37.0	51.90	113.30	7.0
F	1964	5	7	2	34	51.0	51.90	113.30	7.0
A	1964	5	8	9	12	9.0	51.80	106.80	7.0
D	1964	6	18	9	5	7.0	51.50	115.40	7.0
A	1964	6	28	16	51	31.0	51.80	106.50	9.0
D	1964	7	2	9	18	34.0	51.80	115.70	7.0
F	1964	7	14	9	37	12.0	51.90	113.40	7.0
B	1964	10	28	4	21	25.0	50.90	106.70	9.0
D	1964	12	23	22	5	48.0	51.70	115.50	7.0
D	1965	2	26	9	16	41.0	51.80	115.70	9.0
D	1965	5	6	9	43	56.0	51.50	115.50	9.0
B	1965	5	10	11	5	21.0	51.10	106.80	8.0
D	1965	9	7	9	11	1.0	51.80	115.60	8.0
D	1966	1	15	8	55	19.0	51.75	115.50	6.0
B	1966	2	17	7	50	13.0	51.00	106.60	7.0
B	1966	2	19	10	32	41.0	51.00	106.70	8.0
B	1966	2	28	7	37	4.0	51.10	106.70	7.0
D	1966	3	12	7	39	19.0	51.70	115.60	8.0
B	1966	3	14	11	19	53.0	51.00	106.80	7.0
D	1966	4	7	10	18	44.0	51.70	115.80	9.0
D	1966	4	10	1	32	11.0	51.60	115.60	9.0
B	1966	4	12	10	39	7.0	51.10	106.60	8.0
D	1966	4	15	9	14	18.0	51.70	115.60	8.0
D	1966	4	22	9	27	55.0	51.75	115.50	9.0
D	1966	4	27	8	50	43.0	51.80	115.40	9.0
B	1966	5	6	10	32	33.0	51.10	106.70	7.0
D	1966	5	10	9	5	51.0	51.80	115.60	6.0
D	1966	6	15	9	46	17.0	51.80	115.60	9.0
A	1966	8	17	10	10	16.2	51.89	106.40	8.0
C	1966	9	18	23	56	1.0	49.00	106.10	8.0
D	1966	9	28	10	30	58.0	51.90	115.60	9.0
D	1966	10	7	10	12	55.0	51.80	115.30	9.0
D	1966	10	13	11	33	14.0	51.90	115.80	9.0
E	1967	11	1	8	43	53.0	51.60	109.60	9.0
E	1969	3	5	23	57	5.0	51.60	109.40	9.0
C	1969	3	23	6	55	30.0	49.09	106.07	9.0
C	1969	3	23	7	7	47.0	49.15	106.03	9.0

Table 19.6. Seismic events, presumed to be chemical explosions, in two clusters (#1, 50.6°N 112.4°E: and #2, 49°N, 116.6°E) in the Pribaikalye region.

Year	Mo	Da	Ho	Mi	Sec	Latit	Longit	K	Mb	MPVA	MLH	ESSN	ISC	OBN
Cluster No 1														
1965	11	21	1	8	33.0	50.40	112.10	10.0				ESSN		
1965	11	21	1	13	59.0	50.60	112.10	10.0				ESSN		
1965	11	21	1	33	10.0	50.60	112.20	10.0				ESSN		
1965	11	21	3	3	25.0	50.50	112.10	14.0	4.6		5.2	ESSN	ISC	OBN
1965	11	21	4	30	0.0	50.70	111.90	11.0				ESSN		
1965	11	21	7	24	10.0	50.60	112.30	10.0				ESSN		
1965	11	21	16	12	31.0	50.70	112.10	10.0				ESSN		
1965	12	11	1	46	55.0	50.60	112.10	11.0	4.0			ESSN	ISC	
1965	12	14	14	27	26.0	50.70	112.10	8.0				ESSN		
1966	3	12	13	34	38.0	50.60	112.10	11.0				ESSN		
1966	4	6	12	6	57.0	50.80	112.20	10.0				ESSN		
1966	12	26	12	23	28.0	50.50	112.10	10.0				ESSN		
1971	3	21	2	4	50.0	50.50	112.17	9.0				ESSN		
1971	6	11	14	16	53.0	50.55	112.00	10.0				ESSN		
1971	8	14	4	6	3.0	50.51	111.66	9.0				ESSN		
1972	1	31	20	12	18.1	50.60	112.20	9.0				ESSN		
1974	3	20	14	0	11.9	50.77	112.58	9.0				ESSN		
1975	3	5	10	39	24.9	50.53	111.93	10.0				ESSN		
1975	12	1	19	29	8.6	50.66	112.44	10.0				ESSN		
1976	6	8	10	16	56.2	50.25	112.48	9.0				ESSN		
1977	1	28	1	55	25.5	50.77	111.73	9.0				ESSN		
1981	6	24	8	45	14.4	50.51	112.16	10.0				ESSN		
1988	11	19	4	9	56.4	50.52	112.13	9.2				ESSN		
Cluster No 2														
1965	3	18	21	0	42.0	49.60	116.90	12.0				ESSN		
1970	2	24	23	42	18.0	49.10	116.70	9.0				ESSN		
1970	10	7	5	23	0.0	49.60	116.80	10.0				ESSN		
1979	2	6	14	45	14.9	48.95	116.68	14.0	5.1	5.2	4.7	ESSN	ISC	OBN
1979	2	6	19	52	23.5	49.08	116.67	11.0				ESSN		
1979	2	7	15	15	11.3	49.00	116.79	11.0				ESSN		
1979	2	7	18	24	0.7	48.98	116.56	9.0				ESSN		
1979	2	7	19	41	51.7	48.98	116.65	10.0				ESSN		
1979	2	12	13	31	22.1	48.93	116.53	10.0				ESSN		
1979	2	19	20	5	29.3	48.66	116.91	9.0				ESSN		
1979	5	4	1	35	40.2	48.71	116.81	10.0				ESSN		
1979	5	4	1	6	27.7	49.16	116.39	9.0				ESSN		
1979	5	6	4	19	25.8	49.05	116.53	9.0				ESSN		
1979	7	14	6	9	31.9	49.19	116.59	12.0				ESSN		
1979	8	1	3	14	53.6	48.91	116.52	9.0				ESSN		
1979	9	2	22	9	24.2	48.89	116.47	9.0				ESSN		
1980	5	18	7	37	56.9	48.74	116.83	10.0				ESSN		
1980	7	13	16	50	4.7	49.12	116.54	10.0				ESSN		
1982	12	8	11	16	52.0	49.68	116.89	9.9				ESSN		
1983	9	10	10	32	13.2	48.62	116.12	8.1				ESSN		
1983	9	24	19	3	0.5	49.05	116.52	8.7				ESSN		
1985	3	25	13	36	37.7	48.70	116.78	8.8				ESSN		
1986	11	6	17	38	49.1	48.87	116.87	8.8				ESSN		
1987	7	25	0	46	0.8	48.98	116.58	9.1				ESSN		
1987	7	29	21	53	8.7	49.00	116.56	11.0				ESSN		
1990	3	4	7	47	43.0	48.76	116.95	8.6				ESSN		
1990	6	7	2	46	28.6	49.49	116.57	9.3				ESSN		
1990	7	7	8	34	24.0	49.54	116.58	10.5				ESSN		
1990	7	12	0	35	32.5	49.54	116.61	9.9				ESSN		
1990	7	16	22	45	17.3	49.63	116.59	9.5				ESSN		
1990	7	10	1	25	39.6	49.56	116.45	9.2				ESSN		

Table 20.1. Seismic events in Western Siberia, ISC data 1964-1987.

Date	Time	Sec	Latit	Longit		Mb	Ms
		Nuclear explosions					
6.10.67	07:00	2.50	57.71	65.22	33	4.7	
14.08.74	14:59	58.56	68.94	75.83		5.4	
29.08.74	14:59	58.99	67.23	62.14		5.0	
2.10.74	00:59	56.37	66.11	112.65		4.6	
29.09.75	10:59	58.31	69.60	90.46		4.8	
5.11.76	03:59	56.89	61.52	112.73		5.3	
26.07.77	16:59	57.75	69.54	90.51		5.0	
20.08.77	21:59	58.34	64.13	99.62		5.0	
24.08.78	18:00	3.86	65.87	112.56	49	5.1	3.7
21.09.78	14:59	57.65	66.53	86.26		5.2	
7.10.78	23:59	56.96	61.53	112.87		5.2	
17.10.78	13:59	58.04	63.21	63.26		5.5	3.7
6.09.79	17:59	57.74	64.06	99.62		4.9	
4.10.79	15:59	58.05	60.66	71.44		5.4	3.8
7.10.79	20:59	57.08	61.85	113.12		5.0	
10.12.80	06:59	57.66	61.73	66.76		4.6	3.7
22.10.81	13:59	57.47	63.79	97.54		5.1	
4.09.82	17:59	58.55	69.21	81.64		5.3	3.5
25.09.82	17:59	57.37	64.33	91.80		5.2	3.5
10.10.82	04:59	56.88	61.53	112.86		5.3	
25.08.84	18:59	58.74	61.88	72.10		5.3	3.7
17.09.84	20:59	57.66	55.86	87.46		5.0	
6.07.87	23:59	56.93	61.50	112.83		5.1	
24.07.87	01:59	56.93	61.46	112.78		5.1	
12.08.87	01:29	57.05	61.46	112.79		5.0	
1.11.80	12:59	58.02	60.79	97.57		5.2	
	Earthquakes?	Probably	chemical	explosions			
30.11.66	17:28	4.00	67.00	64.00	33	4.6	
26.10.69	20:31	5.00	68.50	119.30	33	3.8	
10.01.70	12:43	34.00	62.40	88.50		4.3	
17.05.70	12:20	30.00	69.00	66.00		3.7	
30.07.70	02:38	12.00	62.00	82.90		5.0	
28.10.71	13:46	19.90	58.90	65.20			
8.10.74	03:07	15.26	60.47	118.30		4.6	
11.02.75	11:21	36.98	66.80	119.70	33	4.3	
3.05.75	06:54	11.44	60.60	95.60	33	4.3	
11.09.76	21:09	27.00	64.4	105.00		3.7	
7.11.76	20:59	54.53	61.79	112.64	33		
13.04.85	04:23	34.00	66.00	71.00			
17.05.89	07:26	39.00	61.37	113.00		4.0	

Table 21.1. A list of 110 seismic events in Eastern Siberia which are probably chemical explosions.

Date	Time GMT	Sec	Lat	Long	K
19.04.68	11:42	5.0	60.60	137.40	9.0
2.04.70	09:57	26.0	65.50	136.60	9.0
8.07.72	22:38	56.0	65.60	136.10	8.0
15.11.72	06:14	56.0	65.10	136.40	9.0
23.01.73	10:33	54.0	65.50	136.60	8.0
5.04.73	16:11	31.0	66.10	136.20	9.0
19.01.74	04:53	18.0	65.30	136.10	9.0
8.03.74	06:28	41.0	65.30	136.40	8.0
11.12.74	09:08	57.0	65.60	136.80	9.0
16.03.75	15:45	51.0	65.50	136.40	9.0
19.03.75	00:51	19.0	65.00	142.60	8.0
10.04.75	07:45	14.0	64.80	142.70	8.0
30.04.75	05:56	7.0	64.80	142.60	8.0
26.02.76	04:08	57.0	65.00	143.00	8.0
5.12.76	08:12	10.0	65.60	136.80	9.0
10.03.77	06:33	7.0	65.50	135.00	8.0
22.11.77	06:42	3.5	66.55	135.59	8.0
21.04.78	09:12	46.0	66.40	136.10	8.0
18.05.78	20:54	49.0	60.30	136.80	8.0
27.07.78	16:13	33.0	65.50	136.80	9.0
14.12.78	18:43	55.0	65.40	136.30	9.0
25.02.79	11:14	46.0	65.40	136.80	8.0
9.03.79	04:54	28.0	65.90	135.00	9.0
20.04.79	04:28	52.2	65.35	143.01	9.0
30.01.80	04:48	49.0	64.80	142.90	8.0
1.06.80	12:12	48.5	66.54	136.21	8.0
19.06.80	07:34	28.6	66.50	136.29	8.0
14.07.80	01:06	42.0	65.50	136.60	9.0
10.11.80	16:15	22.0	65.60	136.90	8.0
13.01.81	06:24	39.0	64.80	142.50	8.0
3.02.81	05:56	34.3	66.46	135.90	8.0
17.02.81	05:23	53.6	66.39	136.23	8.0
17.03.81	17:28	37.0	66.30	135.70	8.0
25.03.81	06:42	46.9	66.25	136.00	8.0
6.04.81	05:07	54.1	66.27	136.10	8.0
13.05.81	11:26	41.0	66.50	136.50	8.0
29.05.81	10:18	29.1	66.37	136.17	8.0
29.08.81	23:59	44.0	65.50	136.30	9.0
30.08.81	00:13	53.0	65.50	136.50	8.0
2.01.82	08:36	21.6	65.43	136.46	8.2
15.01.82	05:03	16.5	66.65	136.50	8.4
18.02.82	08:07	39.6	66.44	136.37	8.2
17.03.82	05:45	22.2	66.29	135.63	8.2
1.04.82	01:49	20.8	66.36	136.06	8.3
15.04.82	09:39	18.4	66.38	136.18	8.8
18.04.82	05:41	29.5	66.37	136.20	8.0
22.04.82	07:25	41.4	65.36	143.49	8.5
5.05.82	06:53	17.5	66.34	136.00	8.2
3.06.82	22:04	25.0	65.10	136.40	8.1
6.07.82	06:16	42.0	65.40	136.60	8.6
6.07.82	06:30	41.0	65.30	135.80	8.0
19.01.83	05:40	37.7	66.57	136.50	7.6
30.01.83	08:01	45.2	66.50	136.44	8.7
1.03.83	07:05	3.3	66.25	136.83	8.8

Table 21.1

25.03.83	08:42	25.6	66.45	136.28	8.3
22.04.83	06:37	42.0	66.50	136.80	7.7
24.04.83	17:57	58.0	65.30	136.70	8.9
26.04.83	11:56	29.0	65.50	136.50	8.4
9.05.83	05:31	36.0	65.90	135.60	8.9
21.05.83	14:39	26.7	66.41	135.72	8.4
7.11.83	16:13	46.2	65.24	135.74	9.0
9.11.83	05:29	18.0	65.50	136.70	8.6
30.11.83	12:47	4.0	65.50	136.70	8.2
11.03.84	06:30	10.2	65.48	136.00	7.9
30.03.84	06:46	26.0	60.20	137.60	7.9
14.06.84	10:09	18.7	64.91	142.39	7.8
29.09.84	11:03	25.1	65.58	136.63	8.6
28.01.85	06:43	42.8	65.51	136.55	8.4
6.02.85	22:40	58.8	65.44	136.59	8.5
13.04.85	13:14	28.0	66.00	136.80	7.7
21.04.85	00:48	52.1	66.42	136.62	8.1
25.04.85	06:57	41.0	60.00	137.60	8.2
30.04.85	12:15	9.0	65.36	143.00	8.2
30.04.85	13:19	43.6	65.37	143.20	7.6
15.05.85	08:36	21.0	60.00	137.60	7.9
17.05.85	08:57	33.0	60.10	137.70	7.9
6.06.85	20:16	1.6	66.42	136.42	8.6
10.06.85	03:09	32.8	65.55	136.78	7.6
10.07.85	09:39	40.0	60.30	137.30	7.8
20.07.85	13:51	33.5	65.05	142.36	7.6
6.01.86	08:17	50.1	66.50	135.56	7.6
15.01.86	05:07	36.0	64.58	143.00	7.7
17.01.86	03:58	7.8	66.42	136.00	7.6
6.02.86	05:49	34.8	60.30	137.30	8.2
24.02.86	08:06	7.0	60.30	137.50	8.3
17.03.86	08:09	1.9	60.04	137.00	8.2
17.04.86	21:06	51.3	65.32	134.85	7.9
26.07.86	10:31	37.4	65.43	136.66	8.2
10.10.86	00:52	42.0	65.20	142.60	7.9
3.11.86	03:55	38.7	65.89	135.80	8.1
22.11.86	17:55	44.9	65.91	136.60	7.9
7.12.86	08:43	23.5	65.77	136.73	7.5
31.12.86	01:27	9.0	60.30	137.20	8.6
12.01.87	02:13	32.4	60.27	137.32	8.2
18.01.87	02:08	32.9	60.36	137.36	8.1
23.01.87	01:26	8.8	60.04	137.71	8.6
31.01.87	01:52	48.0	60.10	137.40	8.6
9.02.87	07:58	9.6	60.18	137.00	7.8
12.02.87	02:09	19.9	64.80	142.87	8.5
15.03.87	01:35	57.0	60.41	137.38	8.5
9.04.87	06:21	7.2	60.34	137.43	7.6
23.04.87	05:09	12.0	60.20	137.20	8.2
15.05.87	07:12	5.0	66.37	135.83	7.7
16.07.87	10:54	29.2	65.38	136.63	7.5
27.04.88	00:55	47.1	60.29	137.40	7.9
29.12.88	21:20	11.1	65.67	136.67	8.4
5.04.89	08:27	40.8	66.03	136.74	8.1
27.12.89	01:51	1.3	65.41	136.42	7.8
3.08.90	05:06	55.3	65.52	136.81	8.2
10.08.90	03:22	12.0	65.40	136.60	8.9

Table 21.1

25.03.83	08:42	25.6	66.45	136.28	8.3
22.04.83	06:37	42.0	66.50	136.80	7.7
24.04.83	17:57	58.0	65.30	136.70	8.9
26.04.83	11:56	29.0	65.50	136.50	8.4
9.05.83	05:31	36.0	65.90	135.60	8.9
21.05.83	14:39	26.7	66.41	135.72	8.4
7.11.83	16:13	46.2	65.24	135.74	9.0
9.11.83	05:29	18.0	65.50	136.70	8.6
30.11.83	12:47	4.0	65.50	136.70	8.2
11.03.84	06:30	10.2	65.48	136.00	7.9
30.03.84	06:46	26.0	60.20	137.60	7.9
14.06.84	10:09	18.7	64.91	142.39	7.8
29.09.84	11:03	25.1	65.58	136.63	8.6
28.01.85	06:43	42.8	65.51	136.55	8.4
6.02.85	22:40	58.8	65.44	136.59	8.5
13.04.85	13:14	28.0	66.00	136.80	7.7
21.04.85	00:48	52.1	66.42	136.62	8.1
25.04.85	06:57	41.0	60.00	137.60	8.2
30.04.85	12:15	9.0	65.36	143.00	8.2
30.04.85	13:19	43.6	65.37	143.20	7.6
15.05.85	08:36	21.0	60.00	137.60	7.9
17.05.85	08:57	33.0	60.10	137.70	7.9
6.06.85	20:16	1.6	66.42	136.42	8.6
10.06.85	03:09	32.8	65.55	136.78	7.6
10.07.85	09:39	40.0	60.30	137.30	7.8
20.07.85	13:51	33.5	65.05	142.36	7.6
6.01.86	08:17	50.1	66.50	135.56	7.6
15.01.86	05:07	36.0	64.58	143.00	7.7
17.01.86	03:58	7.8	66.42	136.00	7.6
6.02.86	05:49	34.8	60.30	137.30	8.2
24.02.86	08:06	7.0	60.30	137.50	8.3
17.03.86	08:09	1.9	60.04	137.00	8.2
17.04.86	21:06	51.3	65.32	134.85	7.9
26.07.86	10:31	37.4	65.43	136.66	8.2
10.10.86	00:52	42.0	65.20	142.60	7.9
3.11.86	03:55	38.7	65.89	135.80	8.1
22.11.86	17:55	44.9	65.91	136.60	7.9
7.12.86	08:43	23.5	65.77	136.73	7.5
31.12.86	01:27	9.0	60.30	137.20	8.6
12.01.87	02:13	32.4	60.27	137.32	8.2
18.01.87	02:08	32.9	60.36	137.36	8.1
23.01.87	01:26	8.8	60.04	137.71	8.6
31.01.87	01:52	48.0	60.10	137.40	8.6
9.02.87	07:58	9.6	60.18	137.00	7.8
12.02.87	02:09	19.9	64.80	142.87	8.5
15.03.87	01:35	57.0	60.41	137.38	8.5
9.04.87	06:21	7.2	60.34	137.43	7.6
23.04.87	05:09	12.0	60.20	137.20	8.2
15.05.87	07:12	5.0	66.37	135.83	7.7
16.07.87	10:54	29.2	65.38	136.63	7.5
27.04.88	00:55	47.1	60.29	137.40	7.9
29.12.88	21:20	11.1	65.67	136.67	8.4
5.04.89	08:27	40.8	66.03	136.74	8.1
27.12.89	01:51	1.3	65.41	136.42	7.8
3.08.90	05:06	55.3	65.52	136.81	8.2
10.08.90	03:22	12.0	65.40	136.60	8.9

Table 22.1. Mines/quarries in the Russian Far East (Primorye).

No/Name	Latit	Longit
p.01 Ussoorisk	44.15	131.8
p.02 Ussoorisk	44.2	132.2
p.03 Ussoorisk	44.7	132
p.04 Ussoorisk	44.7	132.7
p.05 Ussoorisk	45.1	133.6
p.06 Roodnaya pristan	44.6	135.6
p.07	44.7	134.8
p.08	45.6	135
p.09	46.6	134.3
p.10	46.8	136
p.11	44.9	139
p.12	43.7	136.2
p.13	50.6	137
p.14	53.7	134.8
p.15 EKM	52.7	132.7
p.16 Urgalskaya HES	51.2	133
p.17 Booreya-17	49.8	129.6
p.18	54.9	132.2
p.19	54	131.1
p.20	53.1	129.7
p.21	52.2	128
p.22	55.6	129.7
p.23	54.3	129.5
p.24 Amur	53.6	124.8
p.25	54.2	124.7
p.26	54.2	126.2
p.27	54.3	127.4
p.28	54.7	127.4
p.29	55.2	126.6
p.30	56	125.4
p.31	54.5	123.7
p.32	55	124.5
p.33	55.4	123.3

Table 22.2. Seismographic stations in the Russian Far East (Primorye and Priamurye) local network, used in 1990-1991 to locate centers of industrial blasting activty.

	Lat. N	Long.E
1. KRS - Kirovsky	54.4	127.0
2. ZEY - Zeya	53.8	127.3
3. YSN - Yasniy	53.3	128.0
4. BMN - Bomnack	54.7	128.9
5. EKM - Eckimchan	53.I	132.9
6. RMN - Romni	50.9	129.4
7. GRN - Gorniy	50.8	136.4

Table 22.3. Chemical explosions detected by the local network in the Primorye and Priamurye regions of the Russian Far East.

Data	Time GMT	Latit N	Longit E	K
6.02.90	10:13	54.95	124.25	6.8
6.02.90	11:05	54.90	124.45	6.7
15.02.90	05:52	44.55	135.52	7.3
16.02.90	06:19	44.50	135.65	7.6
20.02.90	05:08	53.95	131.05	7.2
21.02.90	05:48	44.58	135.55	7.6
22.02.90	05:16	46.48	134.45	7.9
23.02.90	05:34	51.15	132.95	7.6
24.02.90	09:09	44.25	132.15	8.0
26.02.90	08:03	54.80	124.30	7.3
27.02.90	07:02	54.30	127.10	5.7
27.02.90	08:30	53.05	129.65	7.6
2.03.90	06:41	44.62	132.55	7.7
7.03.90	04:35	46.48	134.20	7.9
15.03.90	08:45	55.20	123.85	8.2
20.03.90	10:01	55.20	123.77	7.0
26.03.90	08:35	55.00	124.52	7.0
29.03.90	00:21	52.96	129.70	7.4
29.03.90	05:12	44.50	135.65	7.5
4.04.90	05:14	55.66	124.75	6.8
11.04.90	03:45	54.95	124.15	7.0
16.04.90	05:19	54.50	123.65	6.9
17.04.90	03:40	54.30	126.10	6.8
22.04.90	21:11	54.85	132.15	6.8
28.04.90	03:30	54.30	123.60	7.0
29.04.90	08:01	55.15	124.70	6.8
5.05.90	04:28	51.15	132.97	8.7
13.05.90	06:19	44.15	131.55	8.0
17.07.90	04:51	44.62	135.45	7.6
20.07.90	05:02	44.65	132.72	7.9
4.08.90	06:45	52.15	128.20	7.6
11.09.90	02:23	53.60	124.75	8.2
15.09.90	10:20	54.65	125.30	7.3
26.09.90	04:39	53.50	124.70	7.9
28.09.90	07:20	54.90	124.20	6.6
18.10.90	06:01	44.70	132.60	8.4
22.10.90	08:14	44.90	139.00	8.3
23.10.90	05:53	44.68	132.60	7.6
3.11.90	03:13	55.20	126.80	7.0
21.11.90	06:46	44.90	132.75	8.2
22.11.90	06:28	44.65	132.75	8.2
22.11.90	07:43	44.40	135.65	8.0
23.11.90	04:53	44.72	132.70	7.6
24.11.90	05:53	55.30	123.30	7.0
25.11.90	05:31	44.10	131.80	8.2
27.11.90	05:05	44.75	132.65	8.1
28.11.90	03:06	44.65	135.65	7.8
29.11.90	05:56	44.70	132.70	8.5
2.12.90	08:13	54.65	127.40	7.7
6.12.90	06:08	44.55	132.80	8.4
7.12.90	06:34	55.50	124.70	7.6

Table 22.3

6.08.91	16:02	55.15	129.69	6.7
7.08.91	05:03	44.60	132.85	7.5
9.08.91	04:46	44.10	131.82	8.6
9.08.91	05:36	52.59	132.82	7.4
14.08.91	18:19	54.30	127.50	6.5
18.08.91	09:00	52.70	132.20	7.4
20.08.91	07:03	54.68	124.60	7.5
22.08.91	03:36	55.36	126.44	6.8
23.08.91	05:28	55.36	124.68	7.4
23.08.91	18:46	55.80	130.05	6.5
27.08.91	06:05	44.45	132.70	8.2
29.08.91	10:38	52.05	127.70	7.5
30.08.91	07:50	49.80	129.75	8.3
11.09.91	19:38	54.30	129.00	9.1
13.09.91	06:57	55.10	124.80	7.6
16.09.91	10:14	55.20	124.30	7.5
28.09.91	07:48	55.00	124.00	8.2
2.10.91	01:16	55.10	126.50	7.0
11.10.91	10:18	53.70	134.80	8.5
18.10.91	07:48	55.50	134.80	8.0
21.10.91	06:29	54.20	124.50	6.8
25.10.91	05:03	55.40	124.40	7.5
27.10.91	11.38	54.00	126.50	6.9
31.10.91	17.57	55.80	129.50	6.6
6.11.91	06:17	55.10	124.30	8.0
20.11.91	18.31	54.20	124.60	7.5
27.11.91	07:58	55.20	124.70	7.6
29.11.91	06:08	55.30	126.60	7.7
16.12.91	06:39	55.10	124.80	7.2
21.12.91	07:16	55.50	124.80	7.6
26.12.91	07:05	54.20	124.60	7.6

Table 22.3

6.08.91	16:02	55.15	129.69	6.7
7.08.91	05:03	44.60	132.85	7.5
9.08.91	04:46	44.10	131.82	8.6
9.08.91	05:36	52.59	132.82	7.4
14.08.91	18:19	54.30	127.50	6.5
18.08.91	09:00	52.70	132.20	7.4
20.08.91	07:03	54.68	124.60	7.5
22.08.91	03:36	55.36	126.44	6.8
23.08.91	05:28	55.36	124.68	7.4
23.08.91	18:46	55.80	130.05	6.5
27.08.91	06:05	44.45	132.70	8.2
29.08.91	10:38	52.05	127.70	7.5
30.08.91	07:50	49.80	129.75	8.3
11.09.91	19:38	54.30	129.00	9.1
13.09.91	06:57	55.10	124.80	7.6
16.09.91	10:14	55.20	124.30	7.5
28.09.91	07:48	55.00	124.00	8.2
2.10.91	01:16	55.10	126.50	7.0
11.10.91	10:18	53.70	134.80	8.5
18.10.91	07:48	55.50	134.80	8.0
21.10.91	06:29	54.20	124.50	6.8
25.10.91	05:03	55.40	124.40	7.5
27.10.91	11.38	54.00	126.50	6.9
31.10.91	17.57	55.80	129.50	6.6
6.11.91	06:17	55.10	124.30	8.0
20.11.91	18.31	54.20	124.60	7.5
27.11.91	07:58	55.20	124.70	7.6
29.11.91	06:08	55.30	126.60	7.7
16.12.91	06:39	55.10	124.80	7.2
21.12.91	07:16	55.50	124.80	7.6
26.12.91	07:05	54.20	124.60	7.6

Table 23.1. Examples of specific large chemical explosions in the Magadan Oblast, for which teleseismic signals have been sought with no success. [A search for detections for these events (described to us by W. Leith, personal communication) was carried out at our request at NORSAR (Frode Ringdal, personal communication).]

shots, in inverse order of charge size:

1990 Nov 22 0545 hours	256 tons total, mine at	63 deg	00 sec N,	146 deg	50 sec E
1989 Dec 01 0420	192	63	00	146	50
1989 Apr 28 0404	160	63	30	146	30
1992 Mar 21 0437	160	62	30	155	30
1991 Mar 23 0356	157	63	00	146	50
1991 Apr 18 0136	156	63	00	146	50
1992 Dec 29 0214	151	62	30	155	30
1989 May 06 0735	150	63	30	146	30
1991 Apr 05 0701	150	62	30	155	30
1989 Jun 07 0302	148	63	10	146	40

shots, in inverse order of rate at which charge was fired:

1989 May 06 0735	1880 tons/sec	63	30	146	30
1989 Feb 23 0544	1380	62	30	155	30
1991 Mar 23 0356	1310	63	00	146	50
1991 Apr 18 0136	1300	63	00	146	50
1992 Feb 23 0516	1250	62	30	155	30
1989 Feb 02 0223	1190	62	30	155	30
1992 Jan 16 0357	1170	62	30	155	30
1991 Dec 18 0156	1130	63	30	146	30
1989 Jan 15 0248	1100	62	40	149	00
1989 Dec 01 0420	1100	63	00	146	50.

Table 24.1. (Upper) Seismic events, presumed to be very large chemical explosions near the Amguemskaya Dam, with K > 10.5.
(Lower) Smaller events near the Amguemskaya Dam, following the large events of May 27, 1976.

	Date	Time	Sec	Latit	Longit	K
1	11.06.71	03:02	35	68.25	178.50	11.0
2	26.09.72	13:45	18	68.33	177.00	11.0
3	26.02.75	14:50	4	69.40	177.50	11.0
4	26.05.76	17:18	44	68.40	177.70	12.0
5	27.05.76	01:46	33	68.50	177.70	12.0
6	27.05.76	02:35	59	68.60	178.00	11.0
7	27.05.76	03:22	8	68.60	177.80	12.0
8	6.03.78	17:55	40	68.30	178.50	11.0
9	6.03.78	18:27	25	68.30	178.50	11.0
10	16.04.81	13:54	34	68.50	178.00	10.6

Date	Time	Sec	Latit	Longit	K
26.05.76	18:26	29	68.50	177.70	8.0
26.05.76	18:32	38	68.50	177.70	9.0
26.05.76	22:19	54	68.40	177.60	8.0
27.05.76	01:52	19	68.50	177.50	9.0
27.05.76	02:42	39	68.40	178.00	8.0
27.05.76	03:14	59	68.50	177.70	8.0
27.05.76	03:45	15	68.40	177.60	8.0
27.05.76	08:25	24	68.60	177.80	8.0
28.05.76	09:43	15	68.50	177.70	9.0

Table 24.2. Seismic events near the Amguemskaya Dam, Chukotka, that occurred during 1100-2300 hours local time, and which are probably chemical explosions.

Date	Time	Sec	Latit	Longit	K
7.07.70	00:41	48	66.66	167.00	10.0
11.09.70	01:17	52	69.33	181.00	8.0
30.03.71	03:48	35	69.50	175.50	8.0
30.08.71	00:24	34	66.25	181.30	8.0
28.06.73	01:20	25	66.50	177.75	8.0
1.03.74	05:52	8	66.30	179.60	9.0
12.09.74	01:55	26	67.60	172.00	9.0
16.11.74	02:02	59	66.60	179.60	10.0
10.12.74	03:27	32	69.00	181.20	10.0
12.03.75	07:35	51	66.60	180.70	9.0
10.05.75	23:55	29	66.50	181.00	10.0
31.05.75	02:17	40	68.70	179.20	8.0
18.02.76	06:52	23	69.20	180.20	9.0
5.06.76	22:25	39	67.60	175.70	8.0
19.11.76	22:13	6	67.60	176.70	8.0
11.01.77	23:14	45	70.10	176.00	8.0
1.03.77	23:09	34	69.40	182.50	8.0
6.05.77	07:49	44	68.50	183.80	8.0
21.07.77	00:11	39	65.50	178.80	9.0
5.09.77	05:02	38	66.60	179.80	8.0
5.09.77	07:23	31	66.60	179.80	8.0
23.09.77	22:01	42	66.10	170.30	9.0
30.11.77	01:58	26	69.40	181.30	7.0
19.01.78	22:59	56	68.70	184.40	8.0
21.01.78	23:46	57	69.20	175.50	8.0
22.01.78	03:09	52	69.20	179.60	9.0
14.03.78	02:43	52	67.10	177.50	8.0
31.03.78	22:51	50	69.00	180.50	8.0
27.01.79	22:23	34	66.50	180.70	9.0
27.02.79	05:37	0	69.10	184.00	7.0
13.03.79	22:27	26	67.20	181.30	7.0
15.03.79	07:29	56	67.10	170.50	10.0
13.02.80	02:06	11	70.46	183.32	
3.04.80	04:46	30	66.60	177.20	8.0
12.04.80	03:56	18	69.70	180.50	7.0
29.06.80	00:05	38	66.20	181.30	8.0
24.08.80	07:57	33	65.80	181.30	8.0
6.11.80	00:23	45	69.90	181.30	8.0
29.12.80	01:24	59	69.70	175.70	8.0
16.03.81	06:41	15	66.40	174.00	9.2
17.03.81	02:40	38	66.40	174.00	9.2
28.04.81	07:18	18	68.50	179.50	8.3
30.11.81	06:21	10	68.50	179.20	8.3
7.02.82	03:53	12	69.50	175.50	8.0
3.03.82	23:37	16	67.80	181.30	6.0
3.03.82	23:50	36	67.80	181.30	6.0
4.03.82	02:40	35	67.80	181.30	6.0
12.03.82	03:00	27	66.60	181.30	8.0
13.03.82	04:50	35	66.90	176.40	7.0
20.08.82	06:42	32	66.00	181.30	6.0
2.12.82	01:31	12	66.10	180.20	9.0
22.12.82	23:14	5	68.60	172.80	8.0
30.12.82	01:22	54	69.10	182.80	8.0
13.01.84	05:42	55	65.20	170.00	8.8
29.02.84	03:13	23	69.85	173.65	8.5
11.04.84	03:37	33	67.50	176.80	7.1
22.04.85	07:00	46	66.60	176.50	9.3
11.06.85	07:23	12	67.00	178.80	7.9
7.06.86	03:16	56	67.20	172.40	9.4
30.12.87	03:24	10	66.40	170.40	9.0
21.04.90	02:15	29	65.52	170.78	9.9
6.06.90	06:43	4	66.90	180.50	9.1
29.08.90	02:36	11	67.56	176.11	9.7
12.12.90	02:54	44	68.01	171.55	9.0

About 30 of them (40 %) are earthquakes

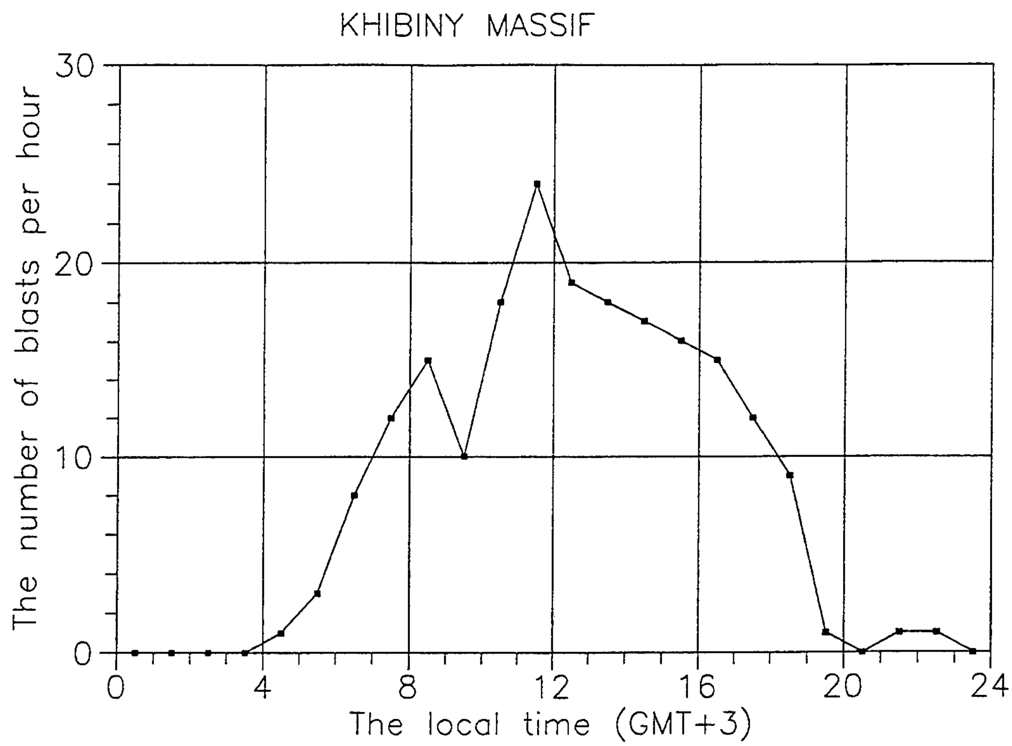

Figure 1.1. Distribution of blasts vs. local time-of-day (GMT+3). Data is for the Apatity seismographic station, Jun 1991 – Sep 1992.

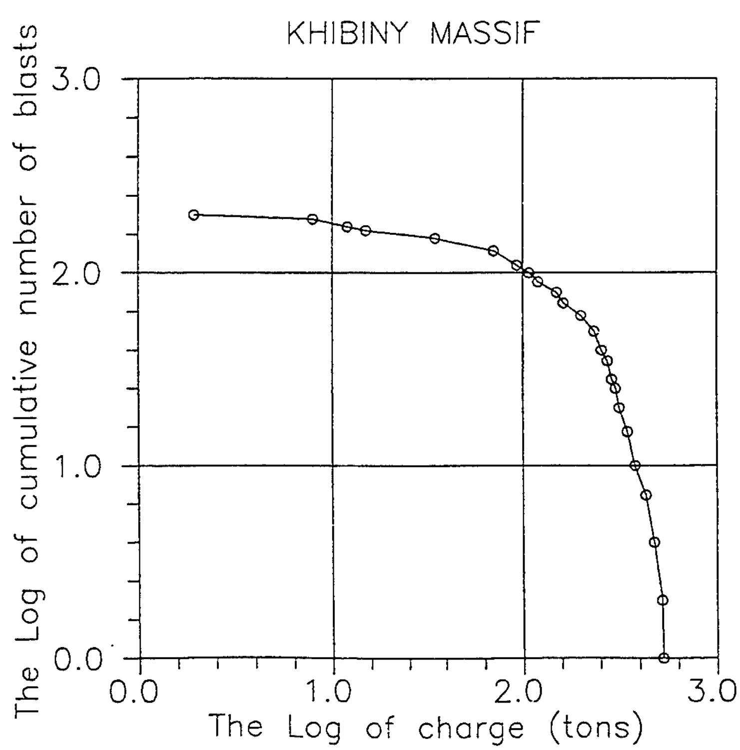

Figure 1.2. The cumulative distribution of chemical explosions in mines of the Khibiny Massif, recorded by the Apatity seismographic station at 17 – 33 km distance, Jun 1991 – Sep 1992.

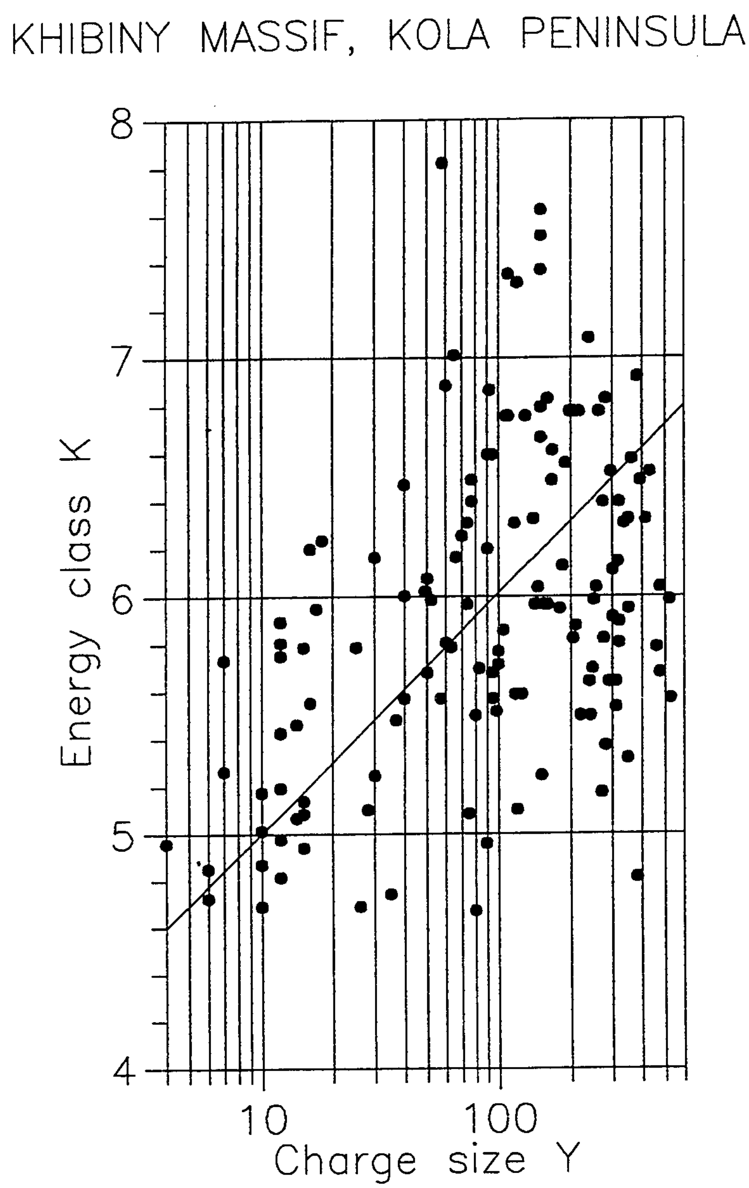

Figure 1.3. The relation between charge size Y (tons) and seismic energy class K radiated by Pg waves. These data are fit by the line $K = 4 + \log Y$.

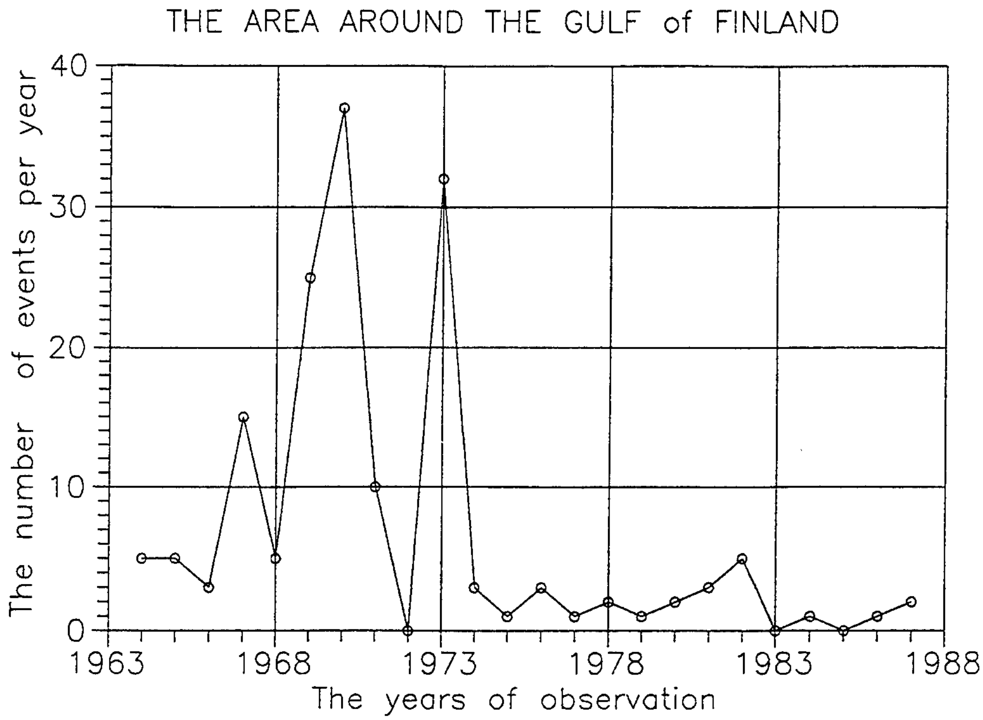

Figure 2.1. The number of presumed chemical explosions around the Gulf of Finland. ISC data, 1964 – 1987.

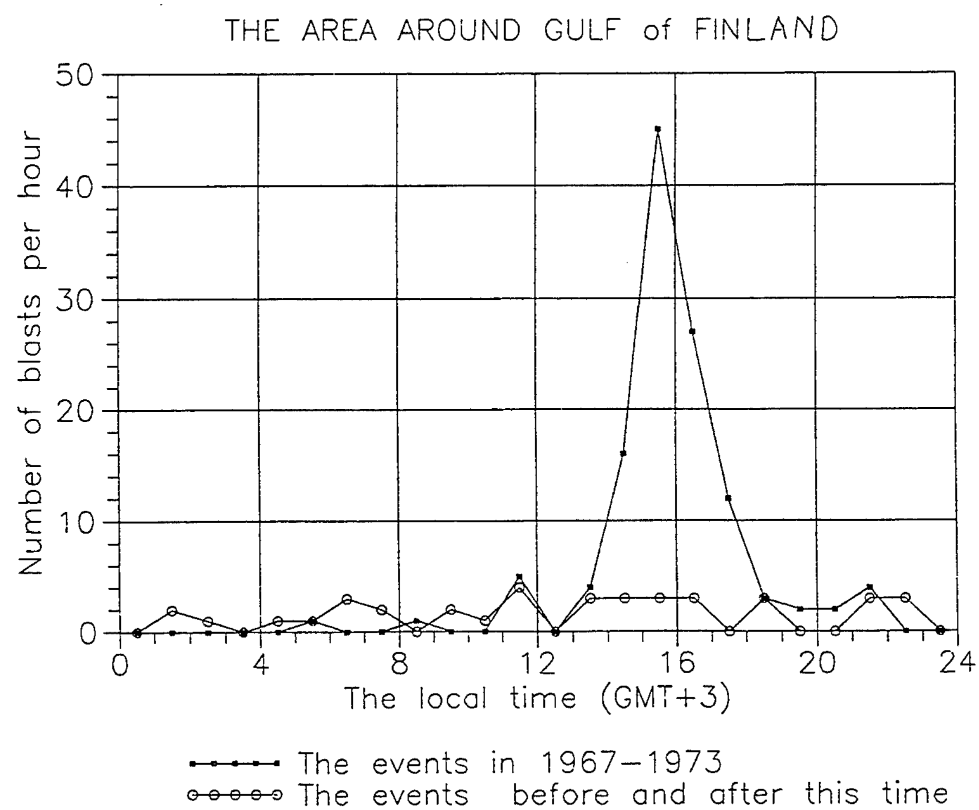

Figure 2.2. The distribution of seismic activity, presumed to be chemical explosions, vs. local time-of-day (GMT + 3), shown separately for years of high activity (1967 – 1973) and for years of low activity (1964 – 1966 and 1974 – 1987). ISC data.

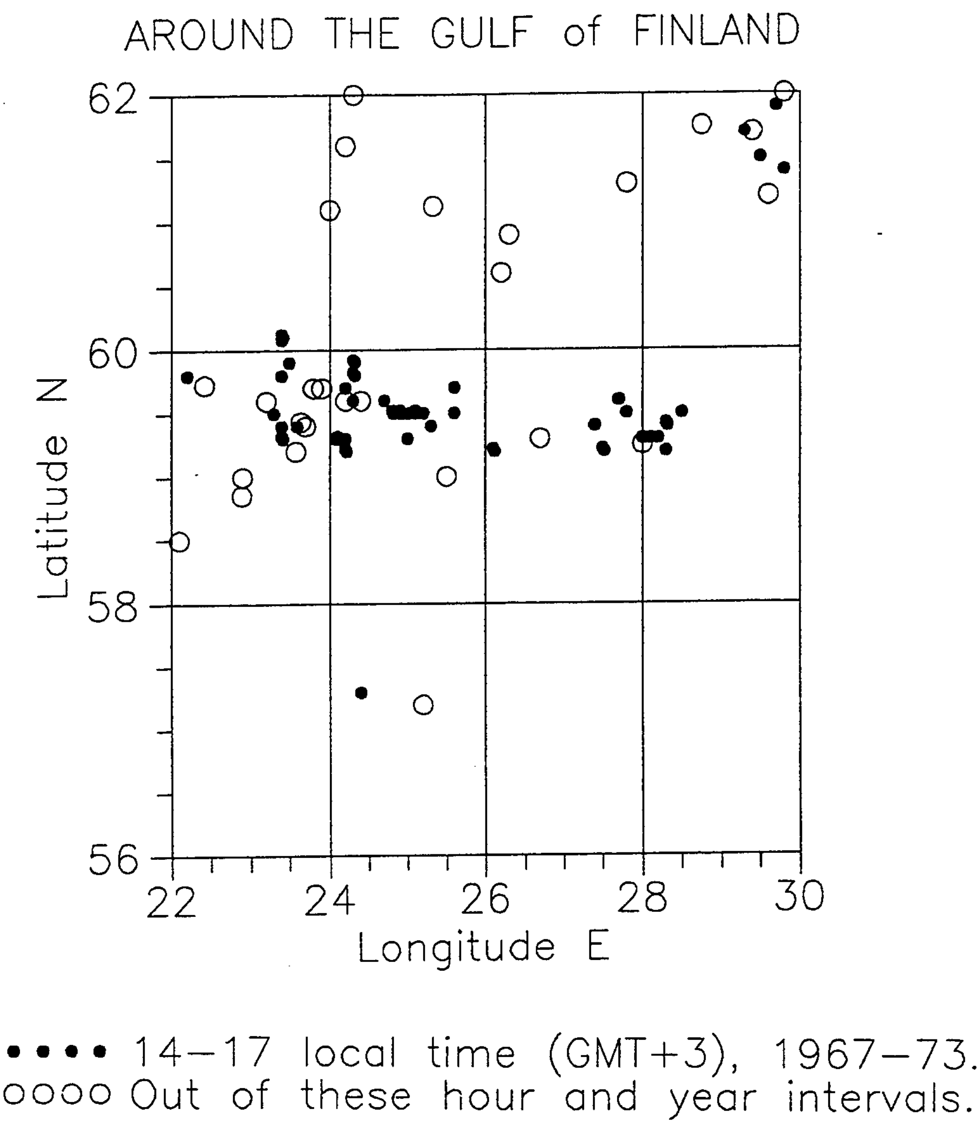

Figure 2.3. Epicenters of presumed chemical explosions in the area around the Gulf of Finland. ISC data, 1964 – 1987. There are 45 events at the location (59.6°N, 25.6°E).

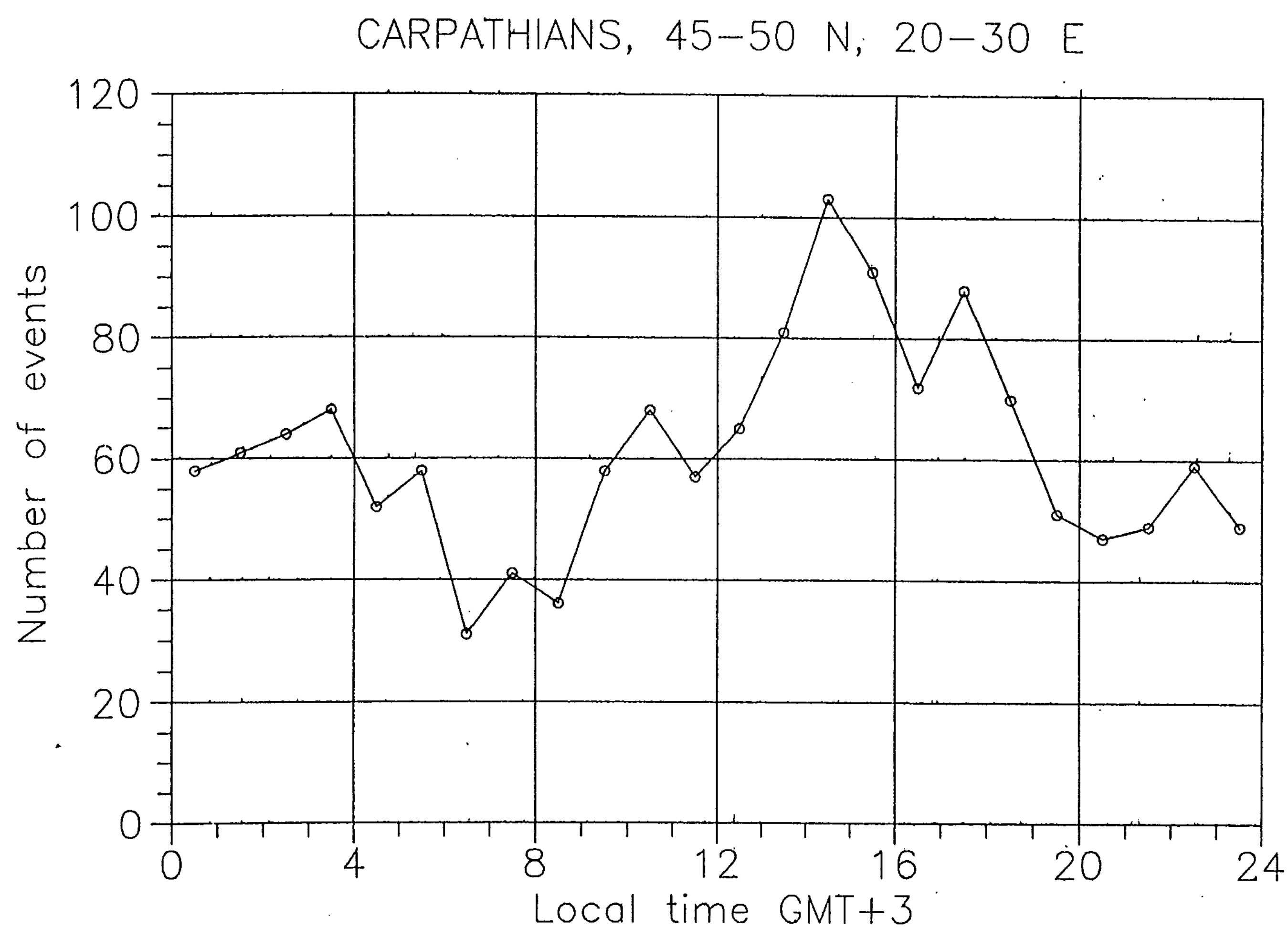

Figure 5.1. Distribution of seismic activity vs. local time-of-day (GMT + 3), in the Carpathians. ESSN and ISC data, 1962 – 1990.

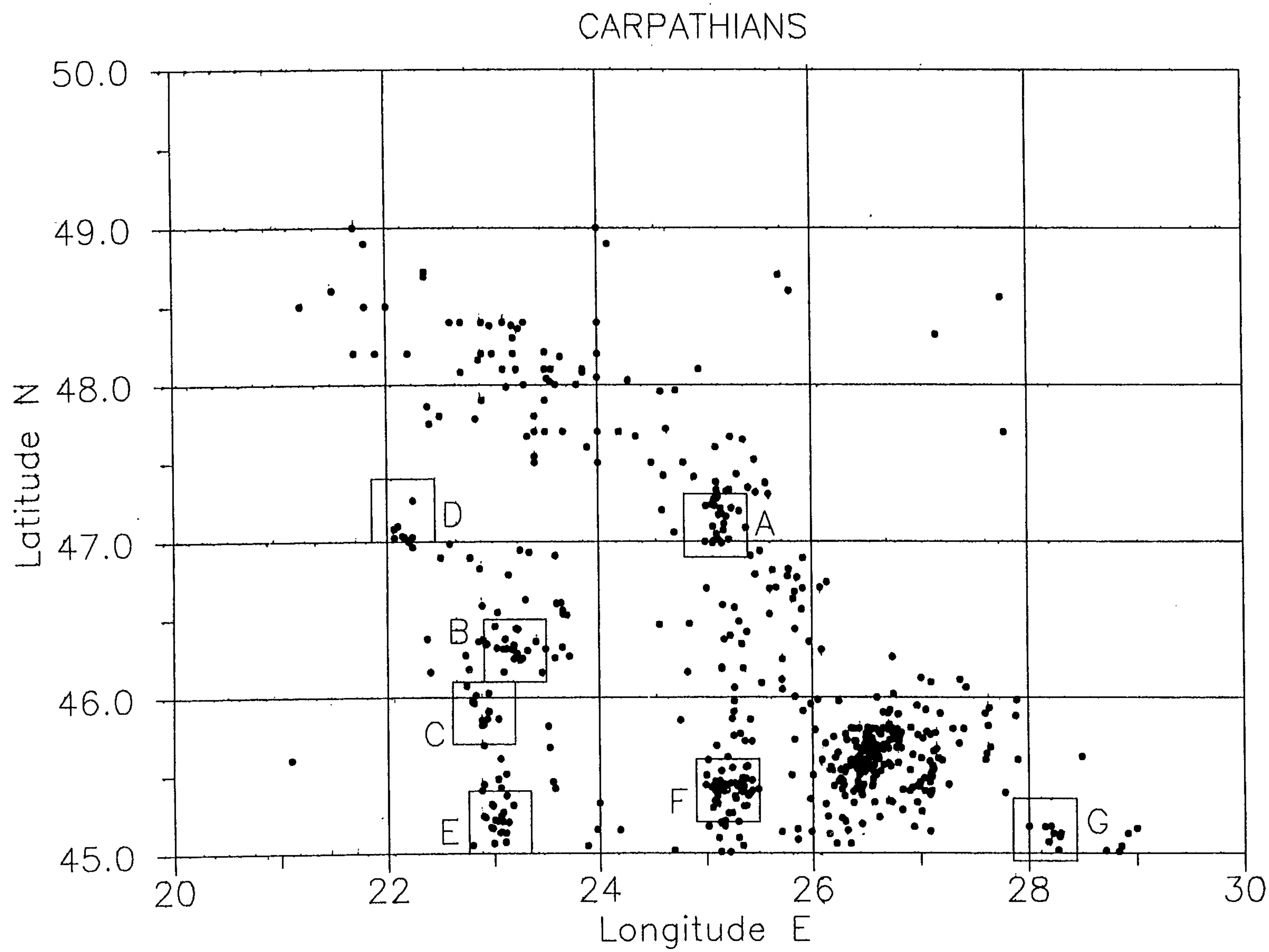

Figure 5.2. Epicenters of seismic events, 1964 - 1987, which occurred during 1000-1500 hours, local time-of-day (GMT + 3). The squares marked A - G indicate clusters of events that we presume are mines or quarries.

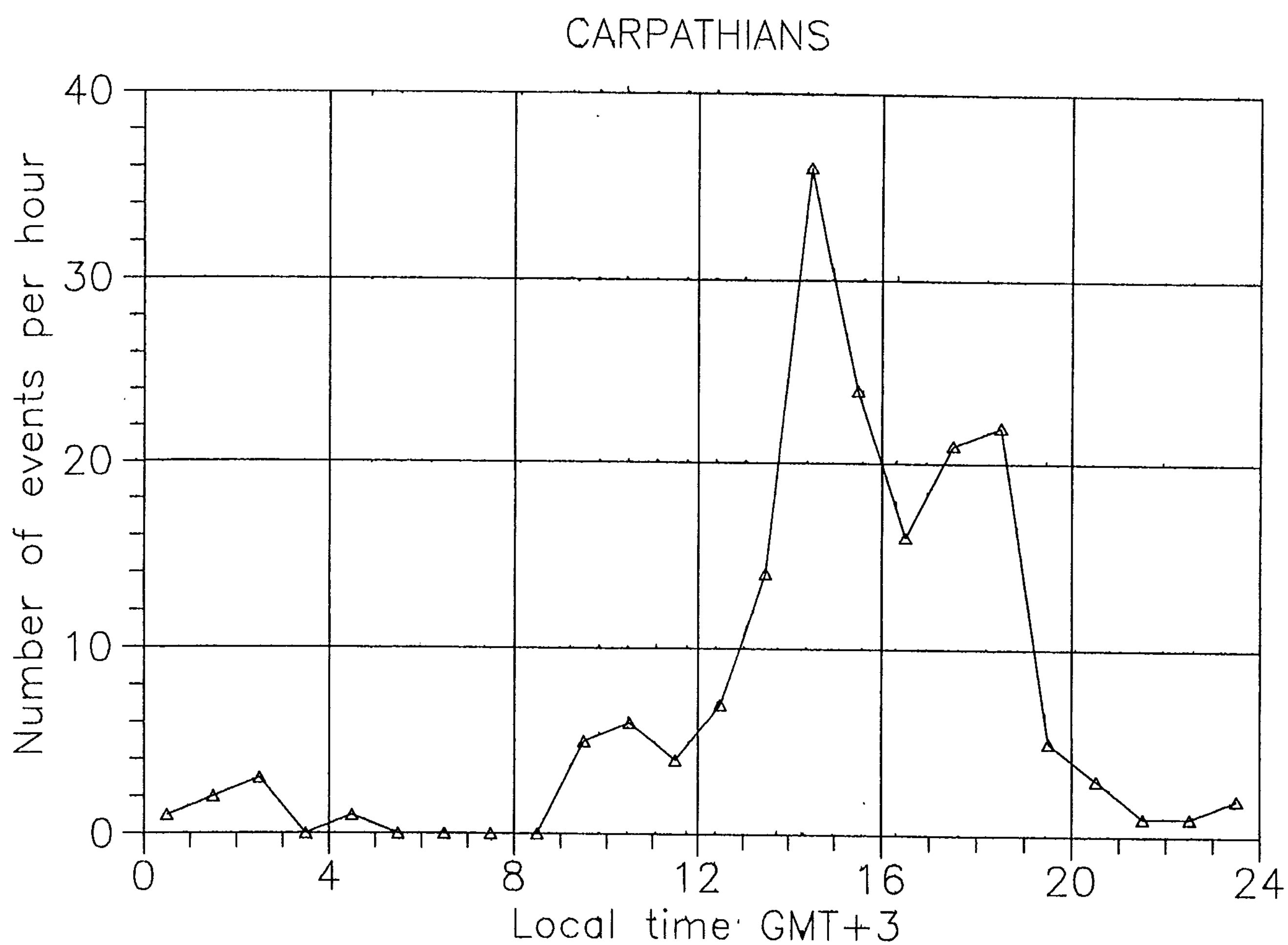

Figure 5.3. The number of events per hour in areas A - G (see Fig. 5.2), which we presume to be mines or quarries.

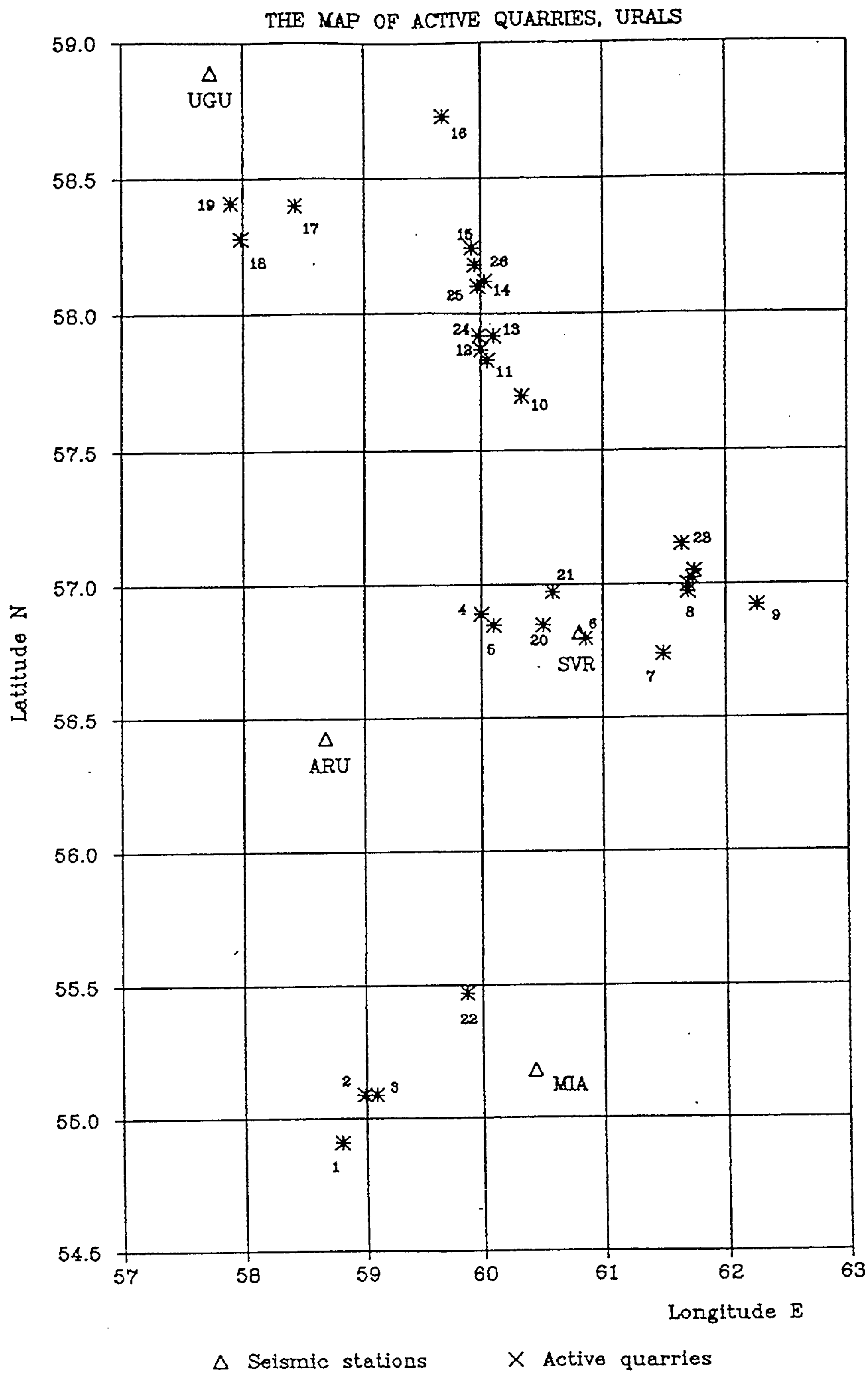

Figure 7.1. A map of active mines or quarries in the Central Urals, from seismic observations during 1973 – 1978. The position of four seismographic stations are shown: ARU - Arti; MIA - Miassovo; SVR - Sverdlovsk; and UGU - Ugleuralsk.

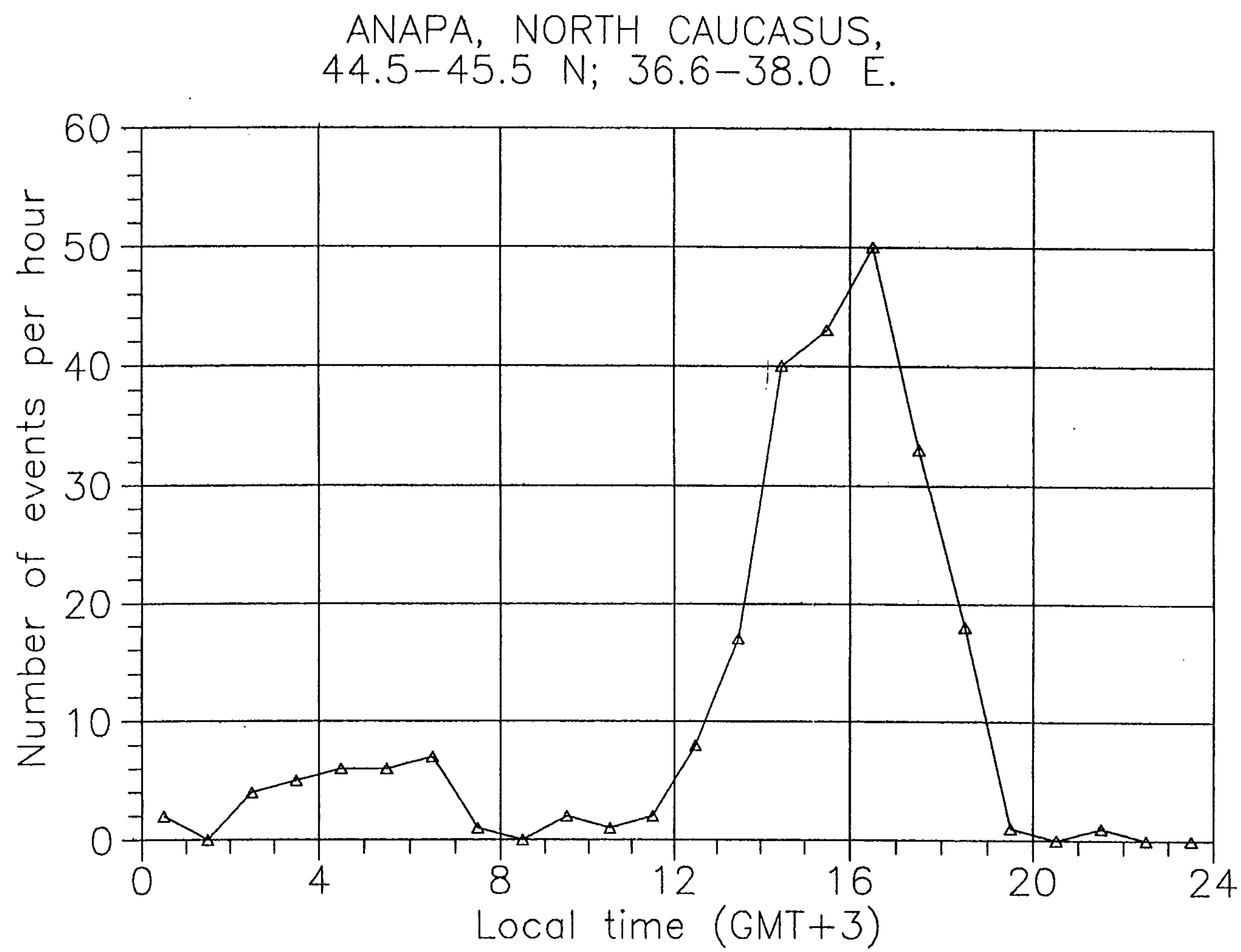

Figure 9.1. Distribution of seismic events vs. local time-of-day (GMT + 3), in the vicinity of Anapa, during 1968 – 1990. Data from Godzikovskaya, 1995. Note the two peaks — a small one during early morning, and a large peak at the end of the daily work time.

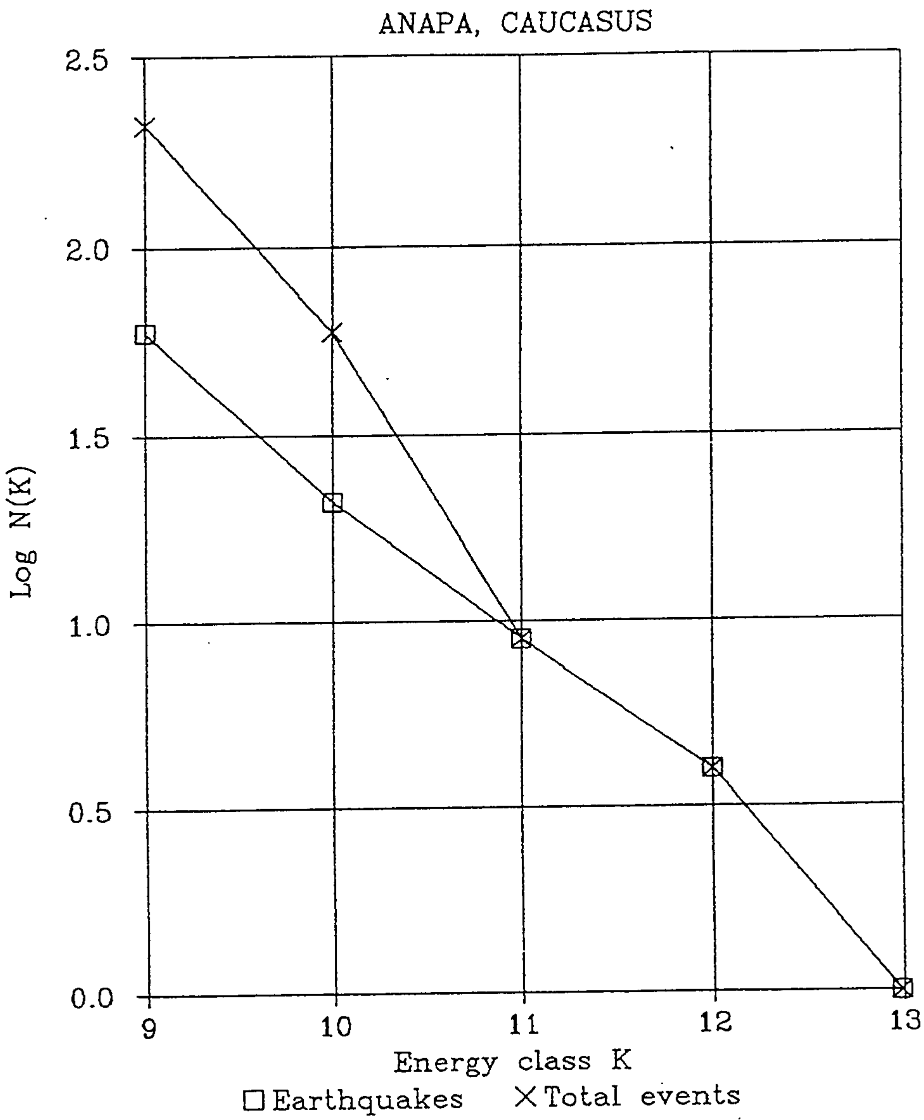

Figure 9.2. The recurrence curve of seismic events in the Anapa region (North Caucasus). Points plotted at each integer K-value give the number of events in the interval from K – 0.5 to K + 0.5. The crosses are the total data before cleaning up those events that are probably blasts. The squares are the data after the catalog has been cleaned up, and are presumed to be earthquakes.

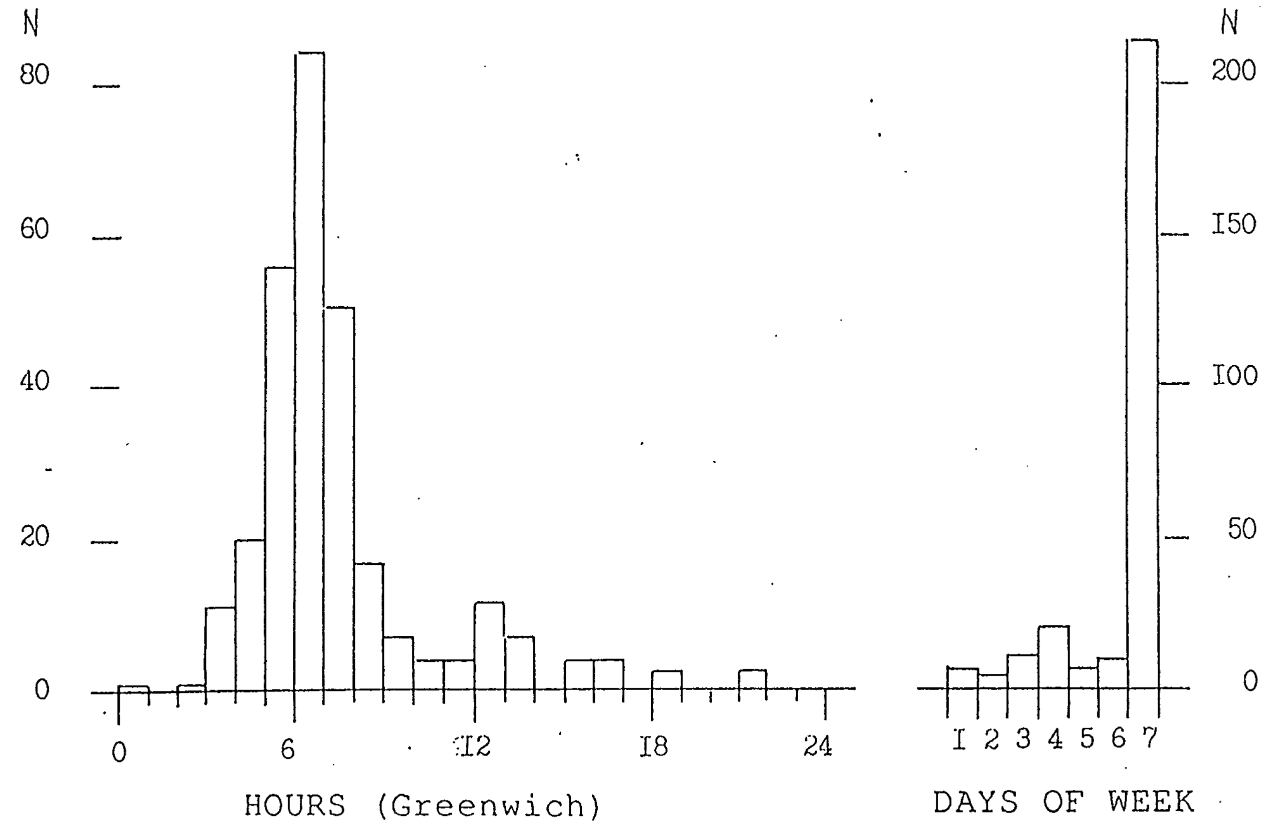

Figure 10.1. Distribution of seismic events vs. time-of-day and day-of-week. Data recorded by the Beyely Ugol seismographic station (North Caucasus, Kislovodsk area) during 1977 – 1982. Most of these events appear to be blasts. Local time = GMT + 4.

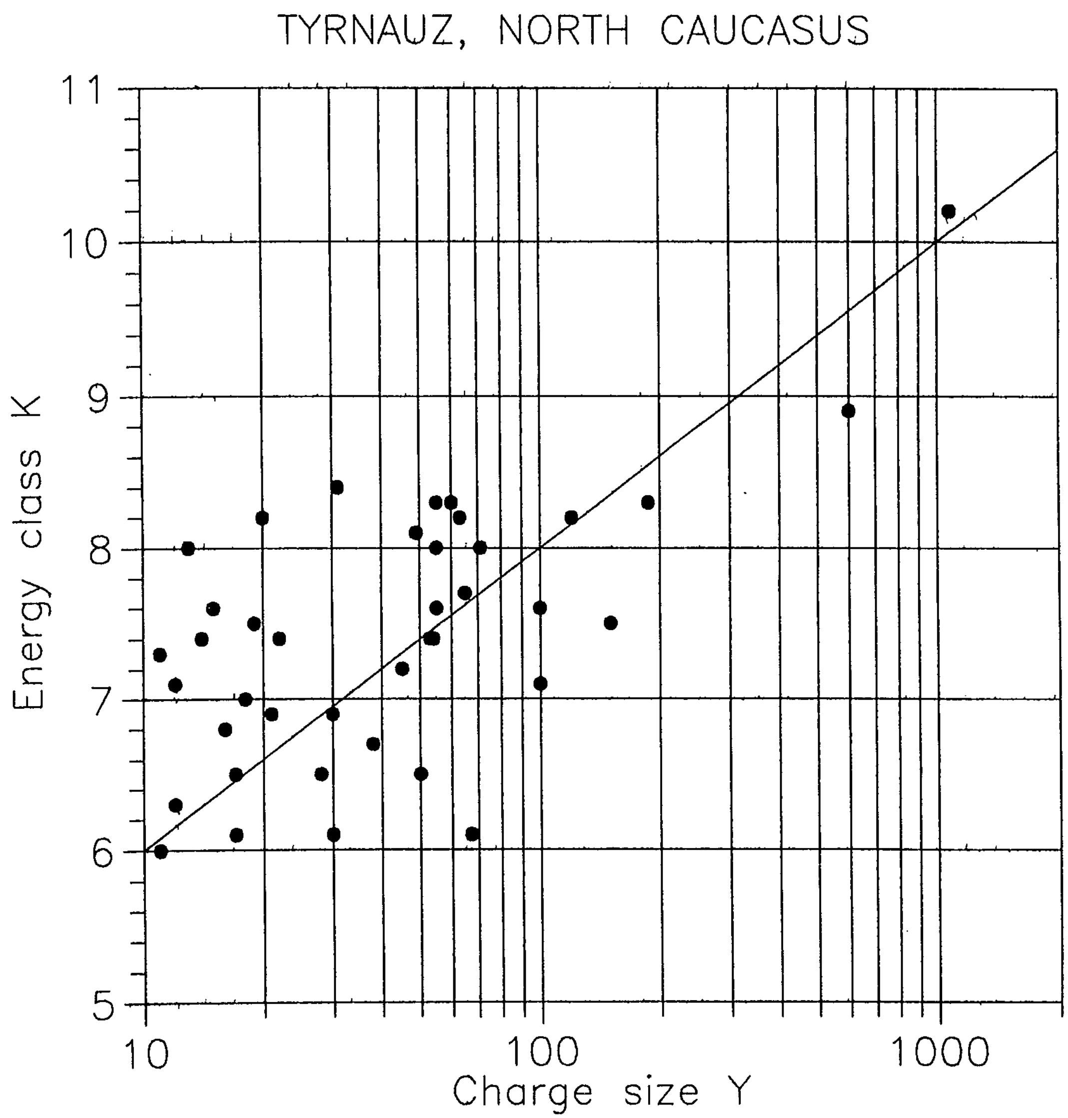

Figure 10.2. The relation between charge size Y (tons) and energy class K, for the Tyrnauz mine. Note that seismic coupling here is much more efficient than for blasts in the Khibiny Massif (compare with Fig. 1.3). Data here are fit by $K = 5 + \log Y$.

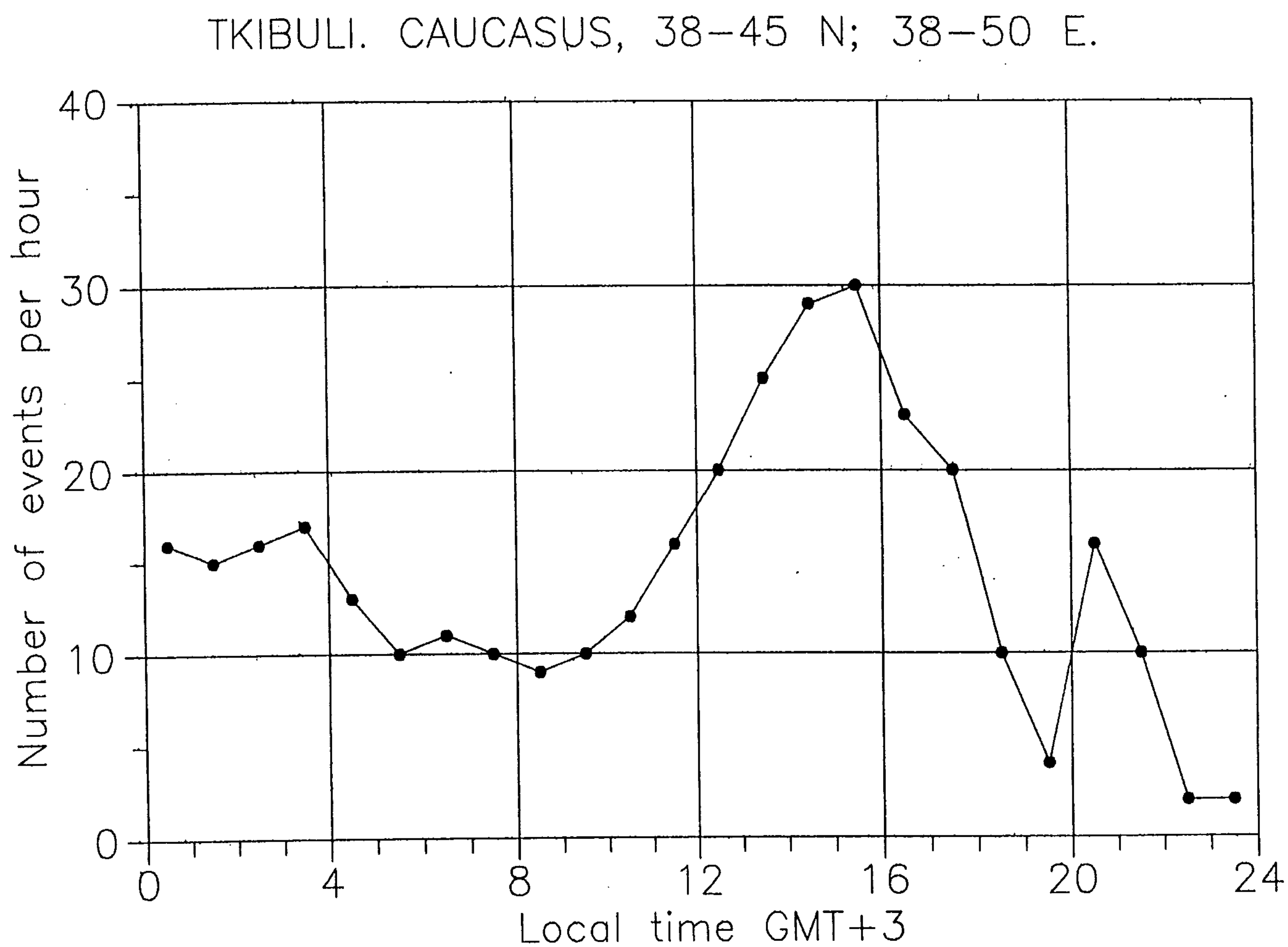

Figure 11.1. Distribution of seismic events vs. local time-of-day (GMT + 3), for the Tkibuly, Southern Caucasus, region. Data from the Beyely Ugol seismographic station, 1974 – 1991 (from Godzikovskaya, 1995). Many of these events are presumably blasts.

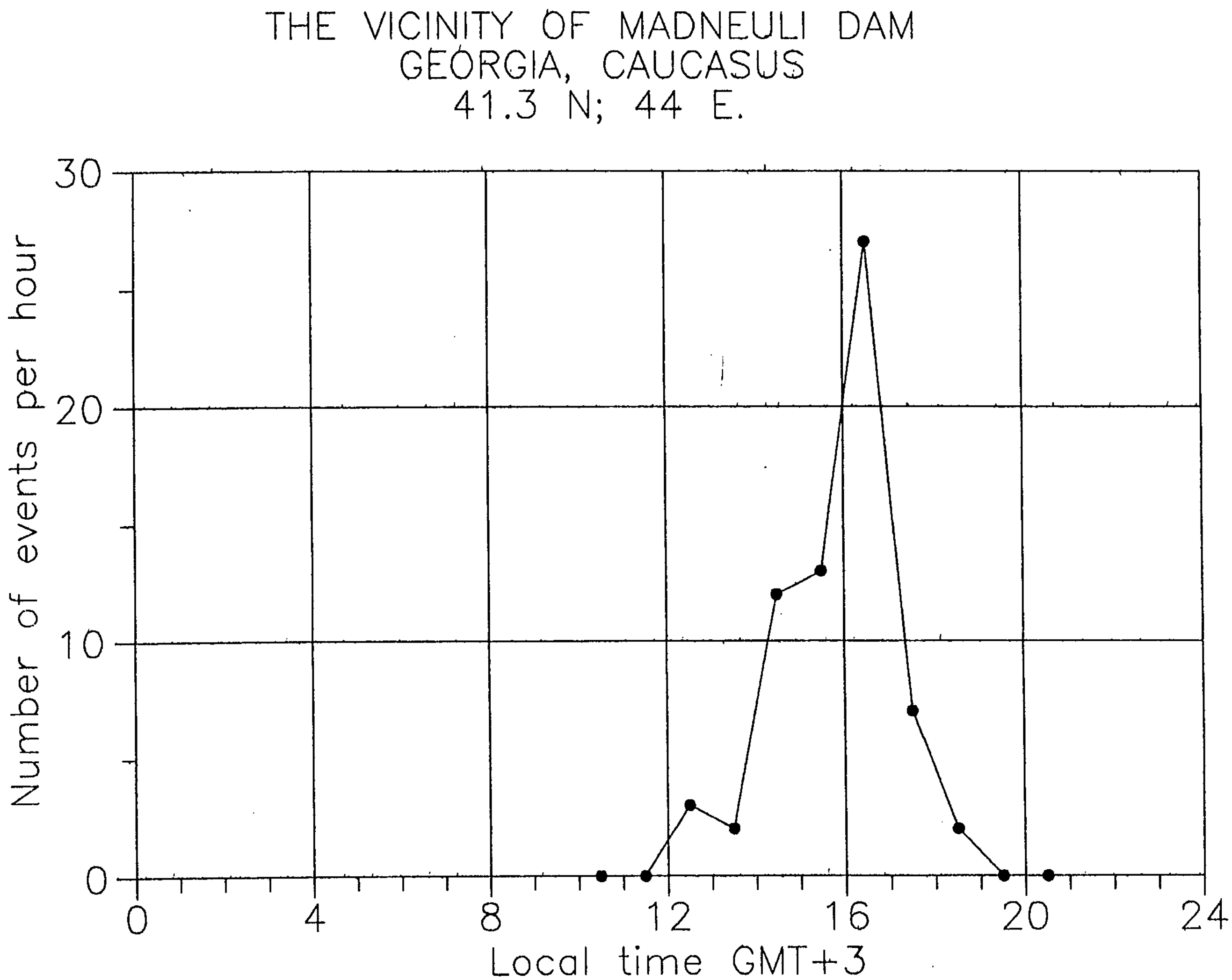

Figure 11.2. Distribution of seismic events vs. local time-of-day (GMT + 3) for the vicinity of the Madneuli Dam, Southern Caucasus, in 1983 (from Godzikovskaya, 1995). Every one of these events is presumed to be a chemical explosion.

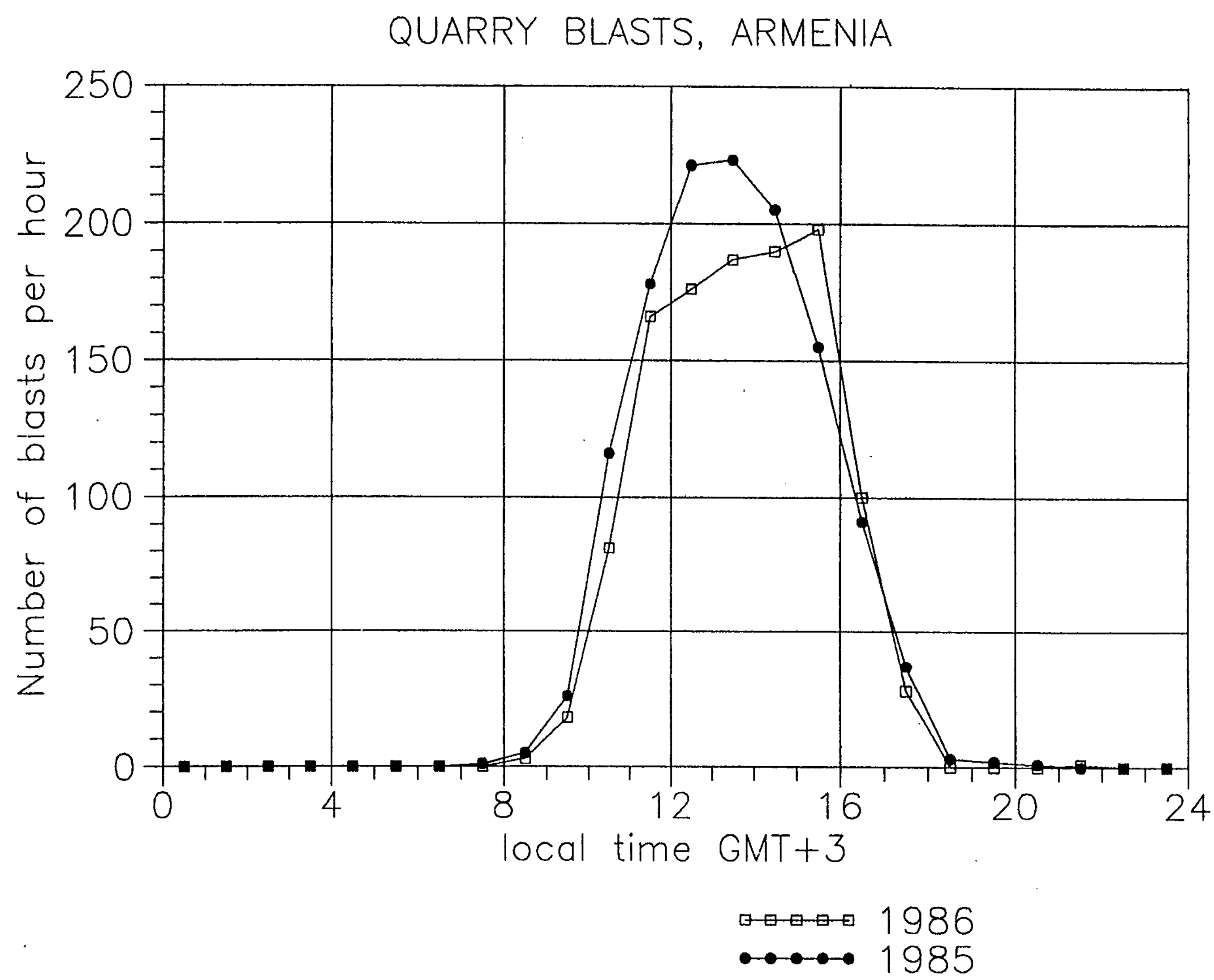

Figure 12.1. Distribution of seismic events vs. local time-of-day (GMT + 3) for presumed blasting in two different years in Armenia (38-42°N, 43-47°E) (Araik, personal communication).

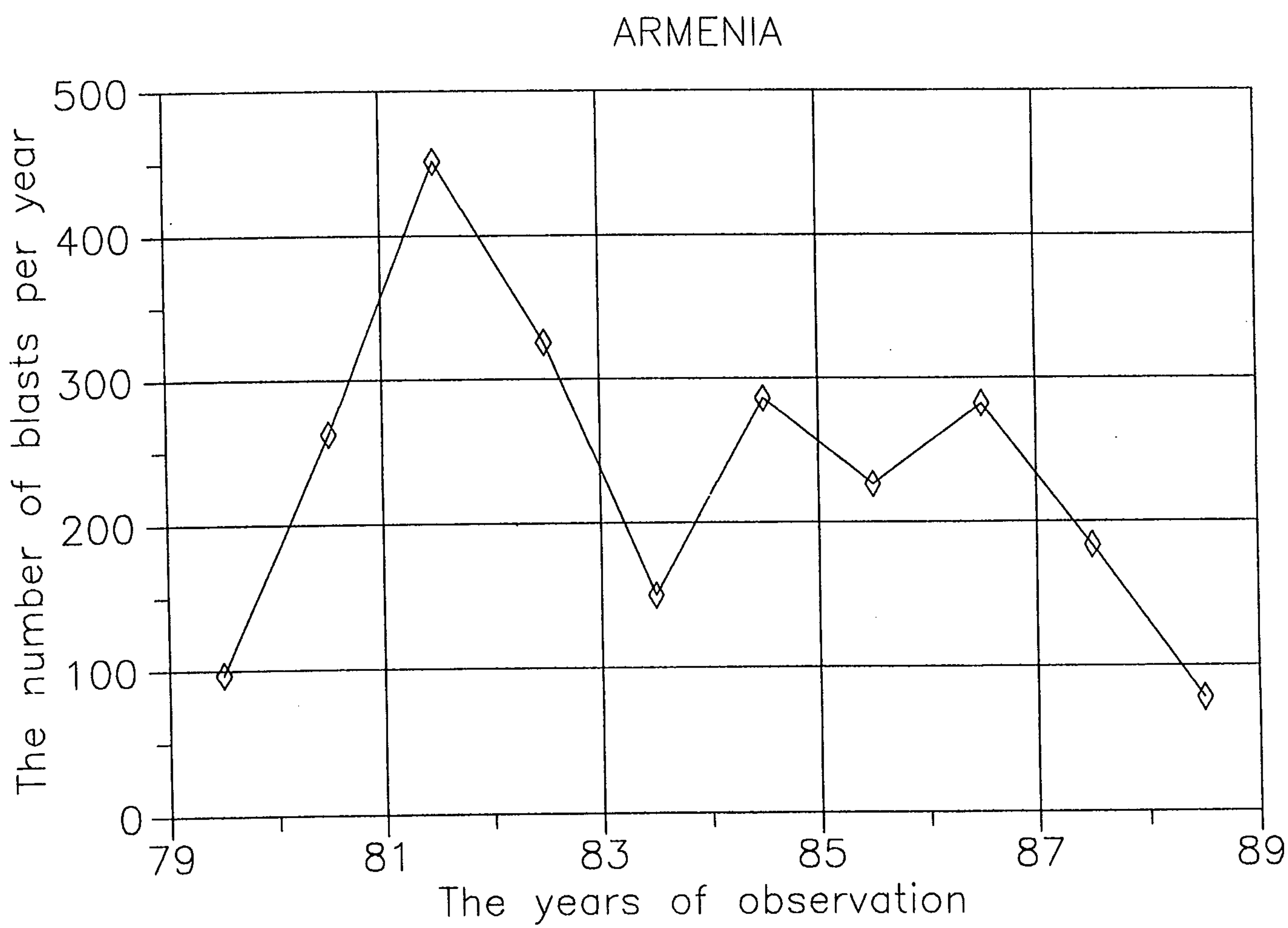

Figure 12.2. Variability in the number of blasts in Armenia, in different years, 1979 – 1989.

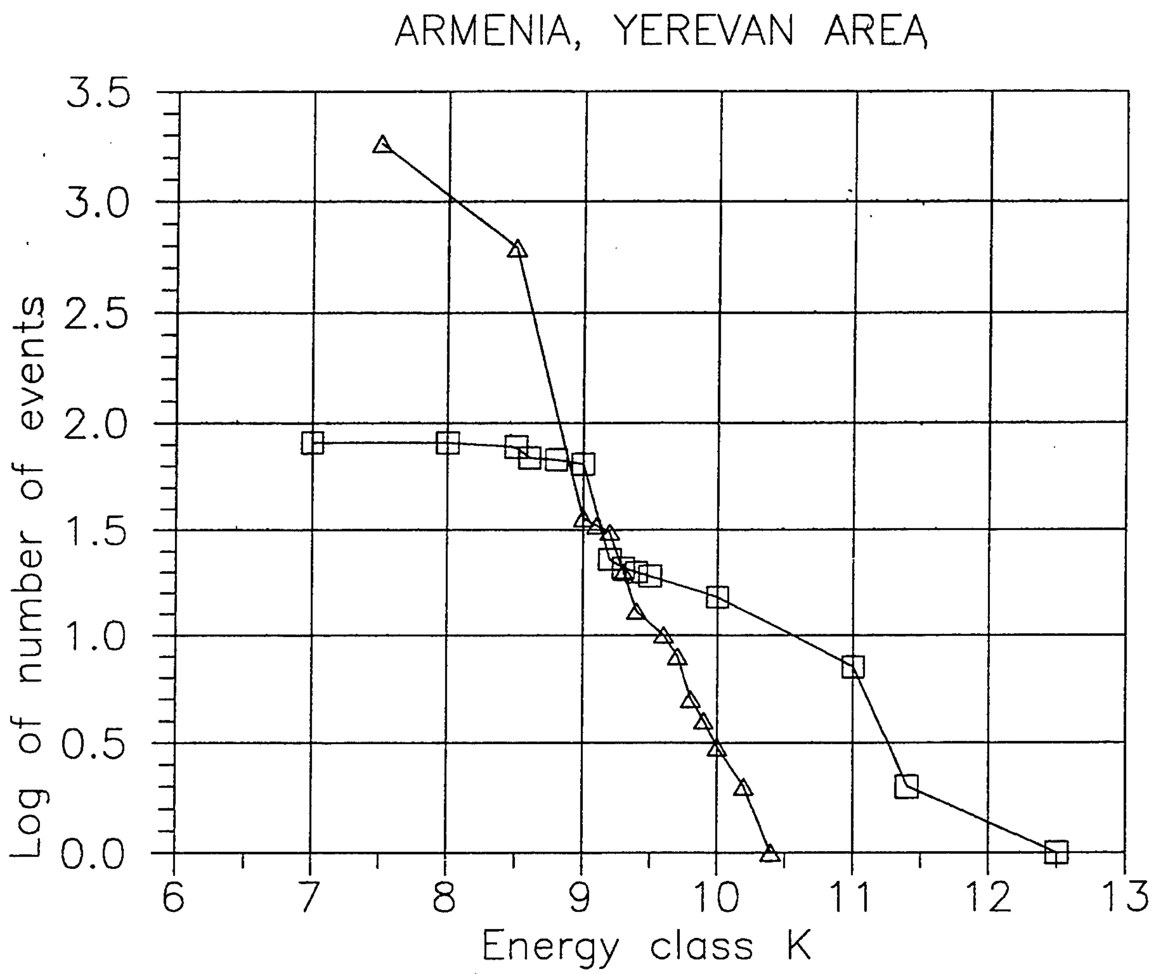

Figure 12.3. The cumulative distribution of seismic events, earthquakes and blasts, at different values of energy class K, for the Yerevan area, Armenia. Blast data are for 1985 – 1986; earthquakes are from the ESSN catalog, 1963 – 1989. (From Araik, personal communication.) Note the steeper slope of the blast distribution - a result that we have found in many regions - indicating a sharp cut-off of blast signals at high signal strength.

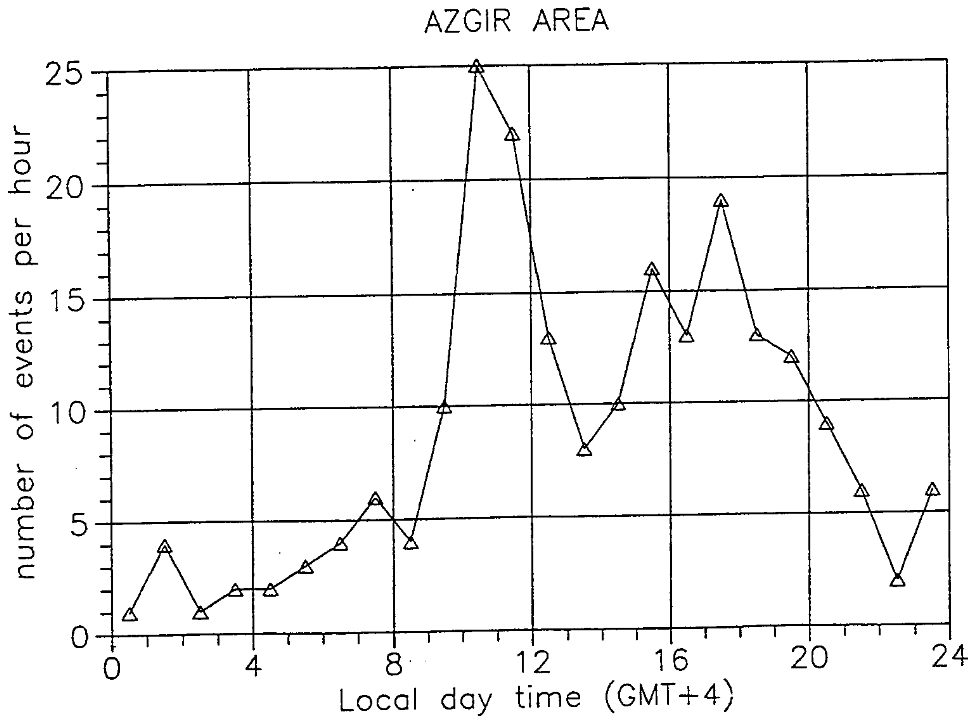

Figure 14.1. Distribution of seismic events, presumed to be industrial explosions, vs. local time-of day (GMT + 4), for the Azgir region. NORSAR data were used for this analysis.

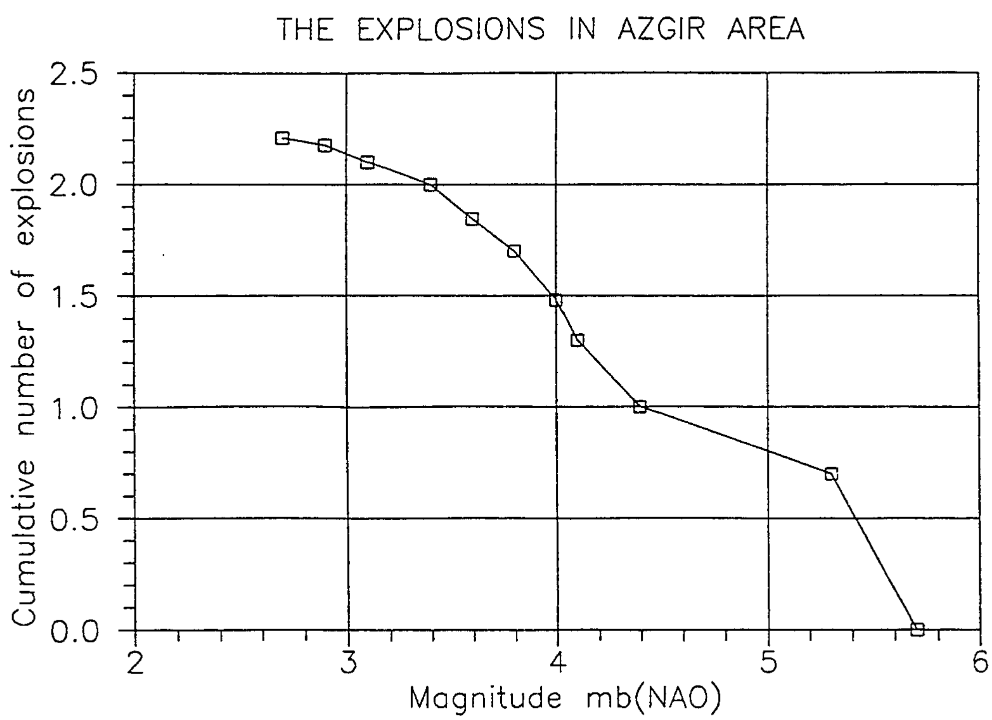

Figure 14.2. The cumulative distribution of chemical explosions, against magnitude m_b(NAO), in the Azgir region.

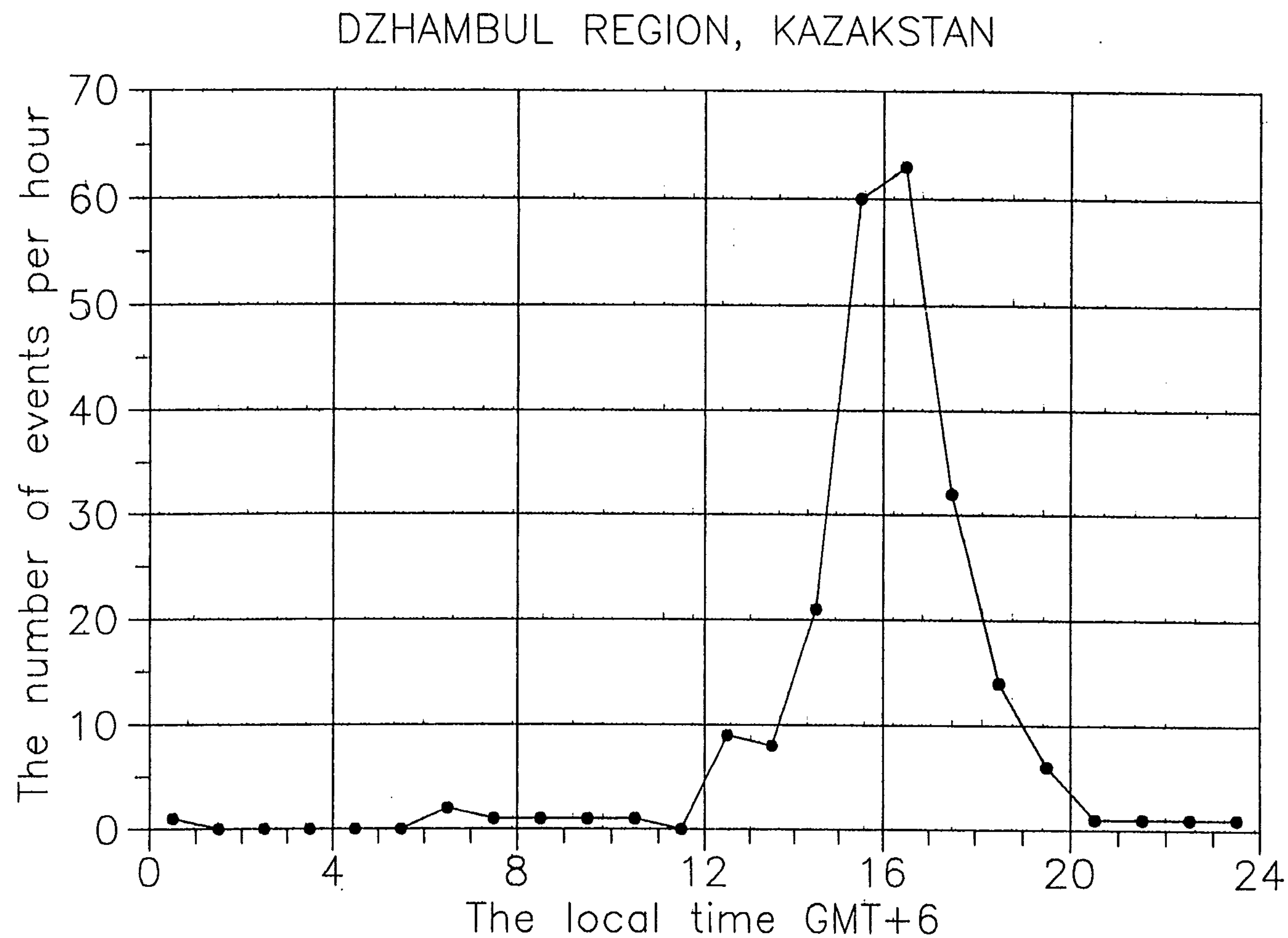

Figure 15.1. Distribution of seismic events vs. local time-of-day (GMT + 6) for the Dzhambul region (41.5-45°N, 68-74.2°E) of Southern Kazakhstan, for the period Jun 1988 – Dec 1991. The dominant peak corresponds to the end of the work day. There is a minor peak that corresponds to the end of the morning work-period.

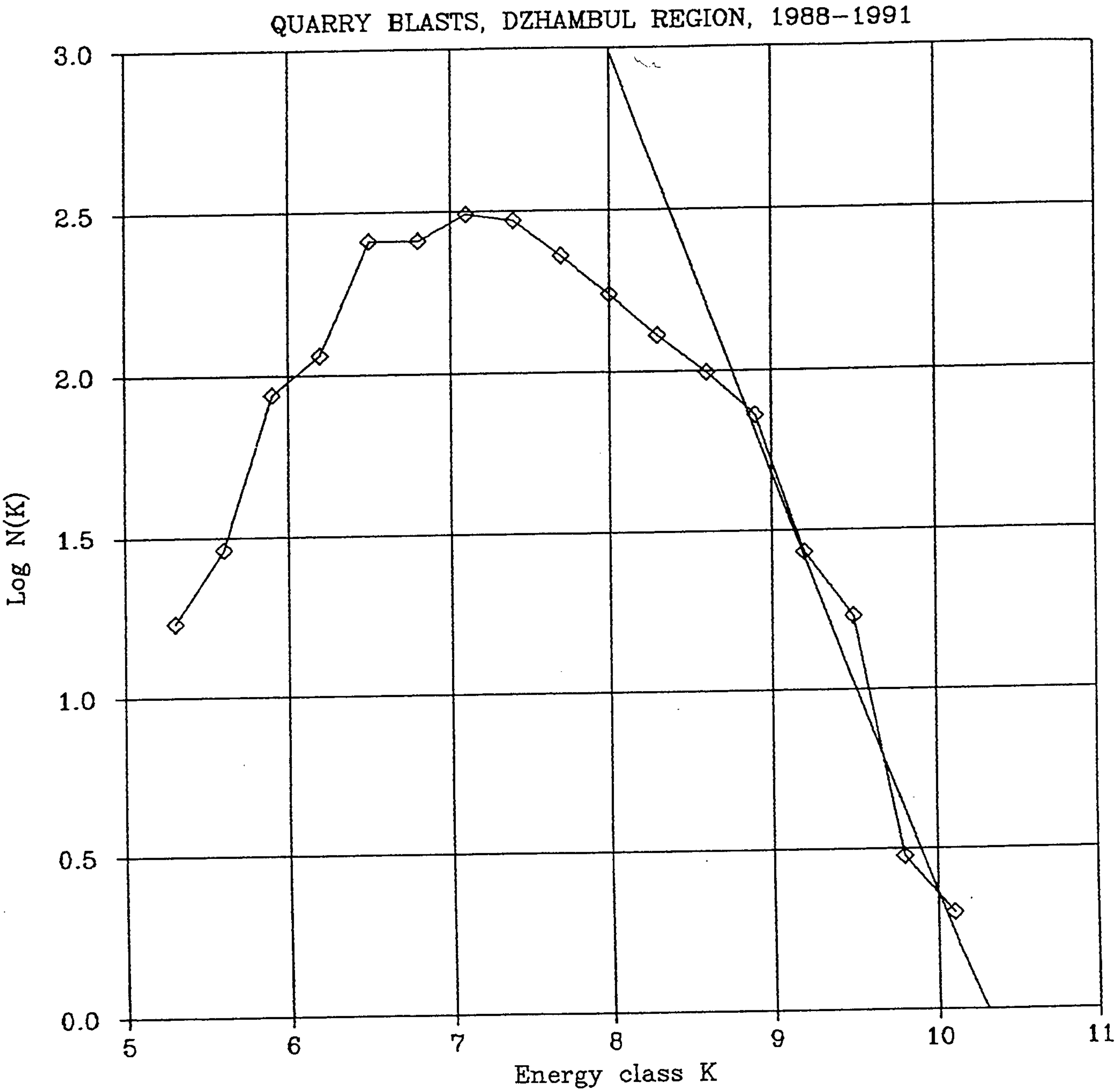

Figure 15.2. The recurrence curve of K values for chemical explosions in the Dzhambul region (Southern Kazakhstan), for the period Jun 1988 – Dec 1991. For larger K values ($8.8 \leq K \leq 10.1$) the slope d log N/dK is −1.3, corresponding to a slope of about −3 on a distribution that uses magnitude rather than K value. Such slopes are much greater than the values −0.43 (for K value) and −1 (for magnitude), typical on similar plots for earthquakes.

THE MAP OF QUARRIES AND SINGLE BLASTS IN NORTHERN TIEN SHAN REGION

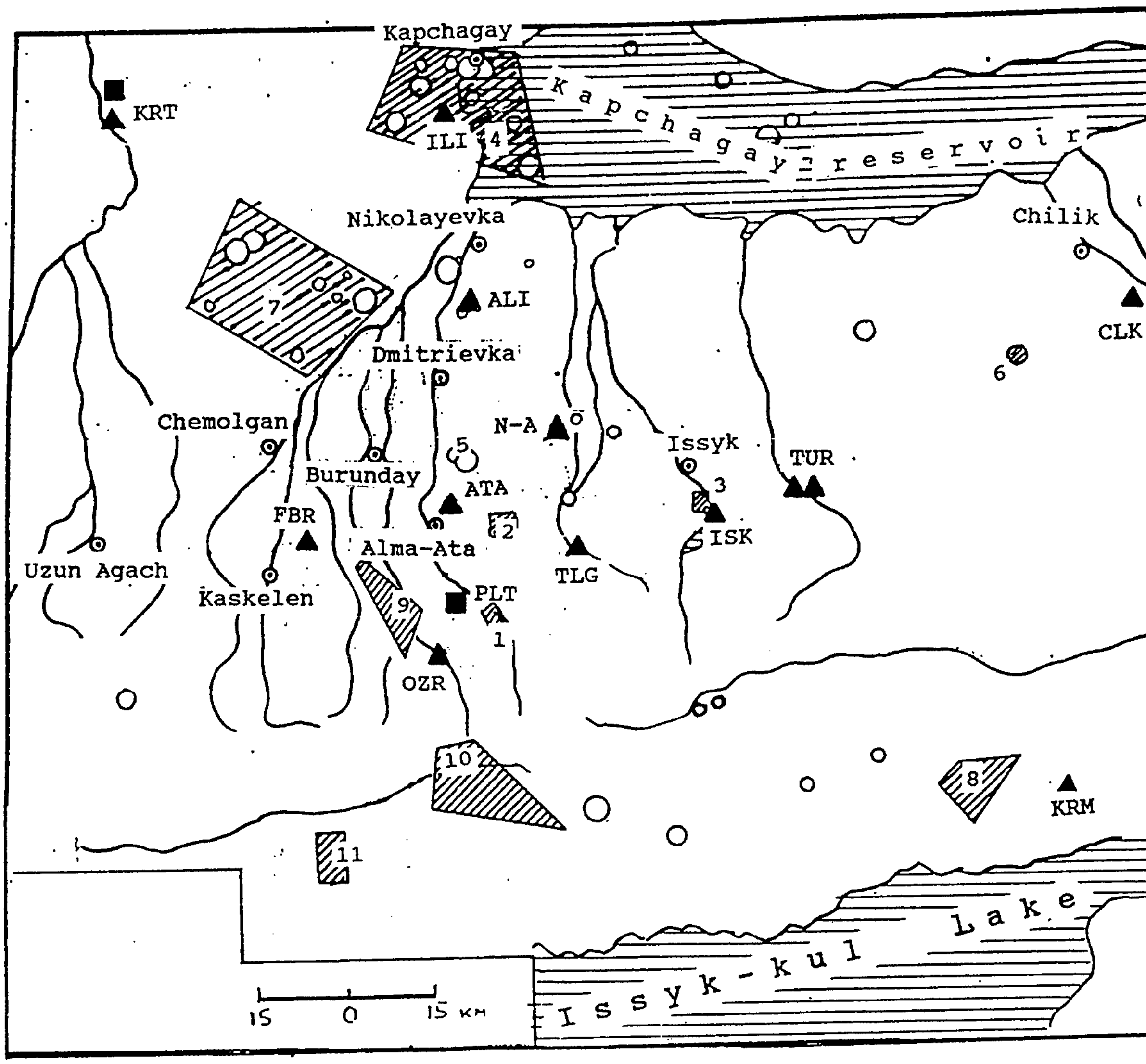

Figure 16.1. A map of mine locations (shaded), single blast locations (open circles), and seismographic stations (triangles and squares) in the Northern Tien Shan region. The number associated with each mine corresponds to the number given in Table 16.1. Squares correspond to two temporary stations: Plato (PLT) and Kurty (KRT). Triangles correspond to permanent seismographic stations: Ili (ILI), Kurty (KRT), Ali (ALI), Novo-Alekseyevka (N-A), Issyk (ISK), Turgen (TUR), Chilik (CLK), Talgar (TLG), Alma-Ata (ATA), Kurmenty (KUR), Fabrichnaya (FBR), and Ozero (OZR).

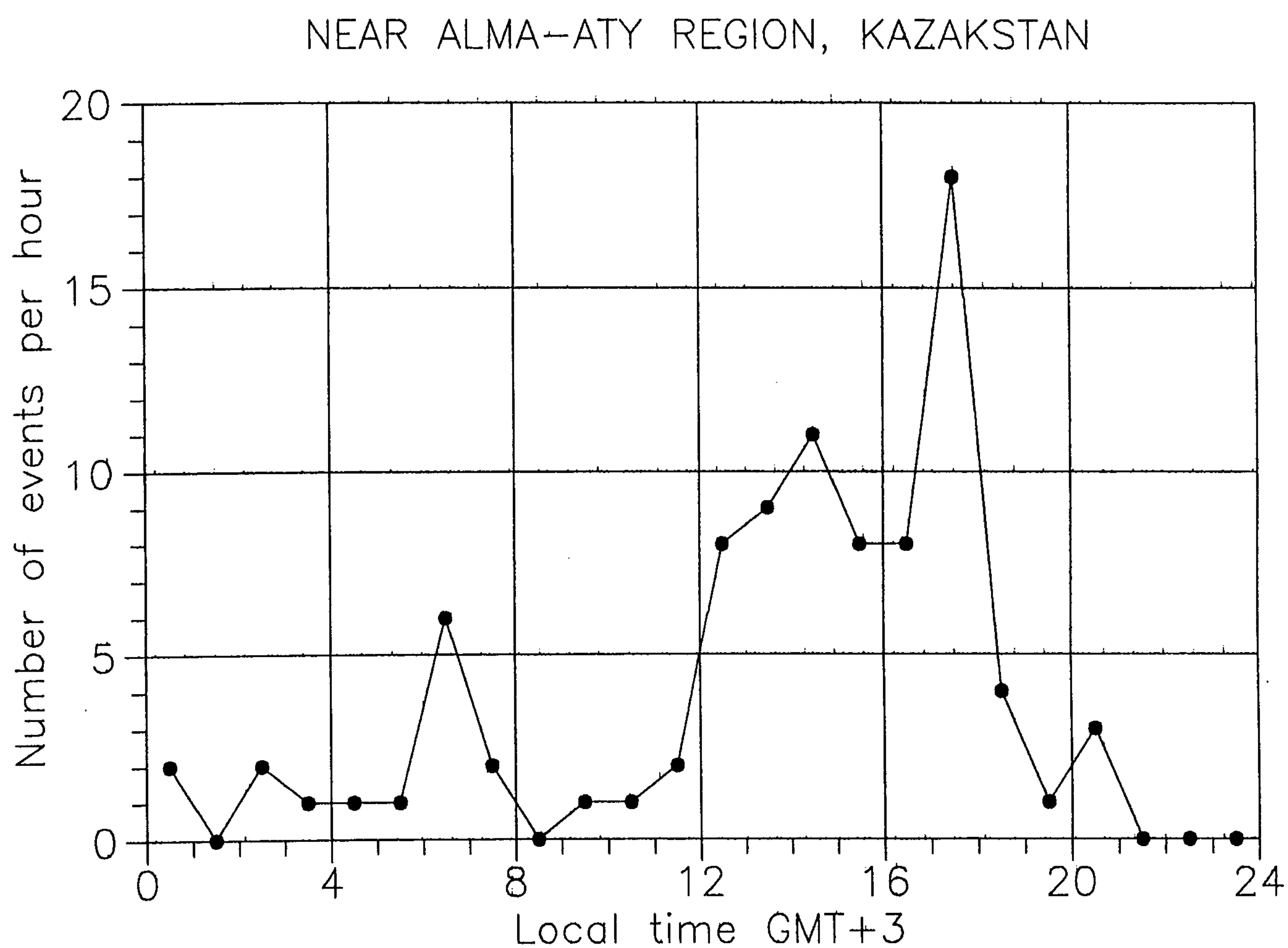

Figure 16.2. Distribution of blasts vs. local time-of-day (GMT + 6) near Almaty (South Kazakhstan).

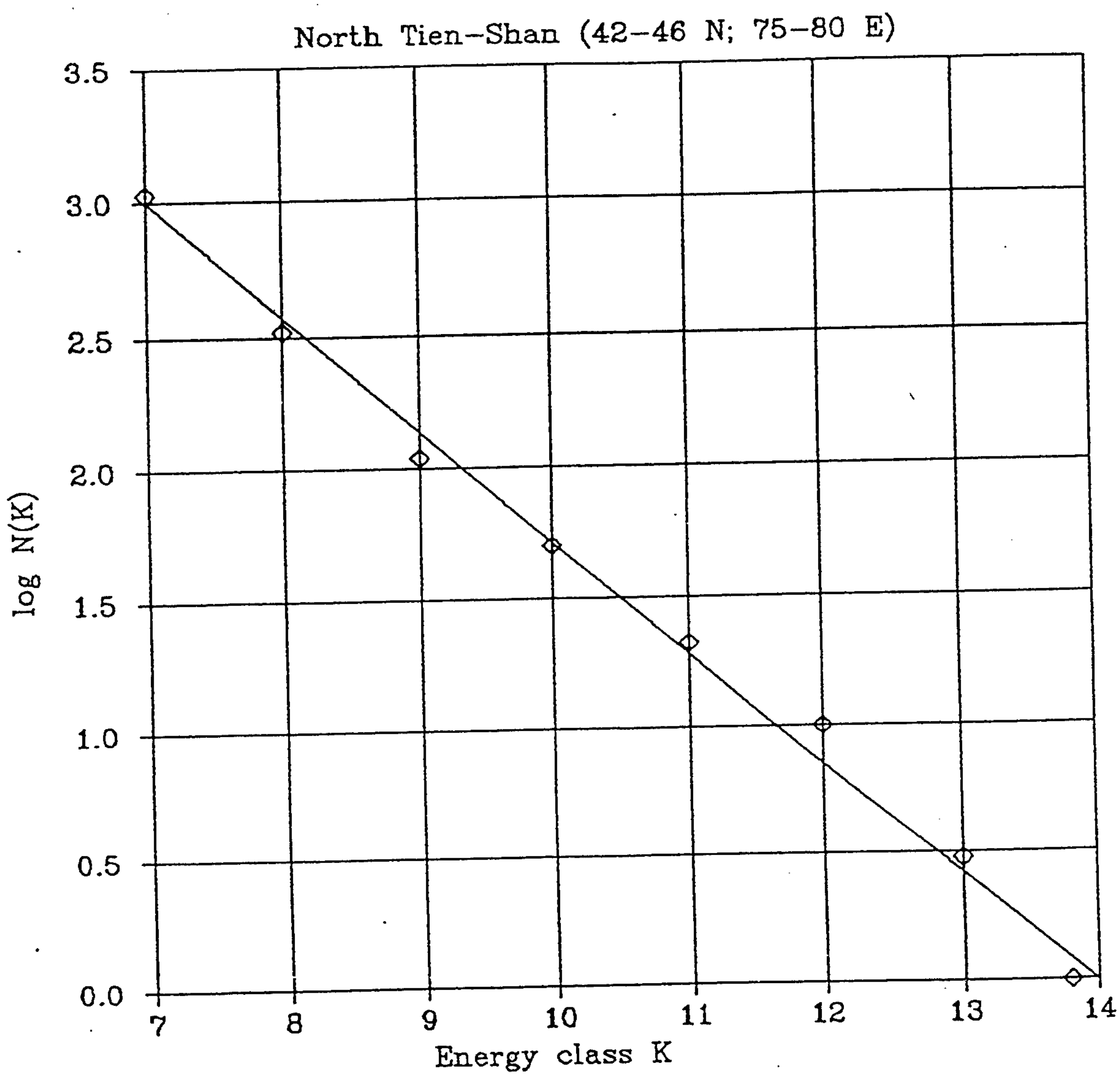

Figure 16.3. The recurrence curve of earthquakes vs. K-value (using cells of width dK = 1) in the Northern Tien Shan region (42-46°N, 75-80°E), for the period 1983 – 1987. The slope is equal to 0.43, corresponding to a slope of –.98 on a typical b-value plot (distribution of magnitudes) (see also Fig. 15.2).

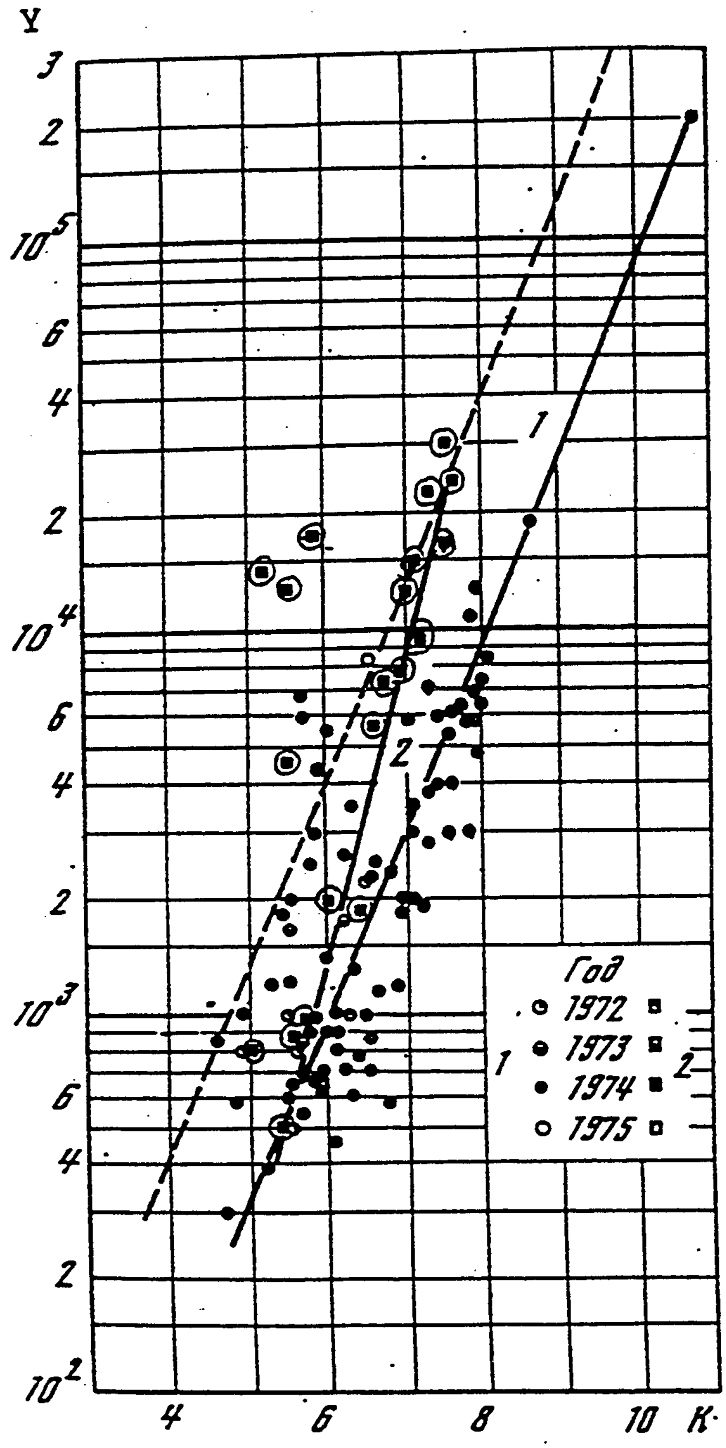

Figure 16.4. Comparison of energy class K and yield Y of chemical explosions in Medeo (solid circles, and line 1), and in Kotur-Bulak (solid squares inside circles, and line 2). For Medeo the line is given by $K = 0.05 + 2 \log Y$. For Kotur-Bulak the line is $K = 1.5 + 1.4 \log Y$, (i.e. K increases more slowly with yield). The scatter of points in this Figure is quite large.

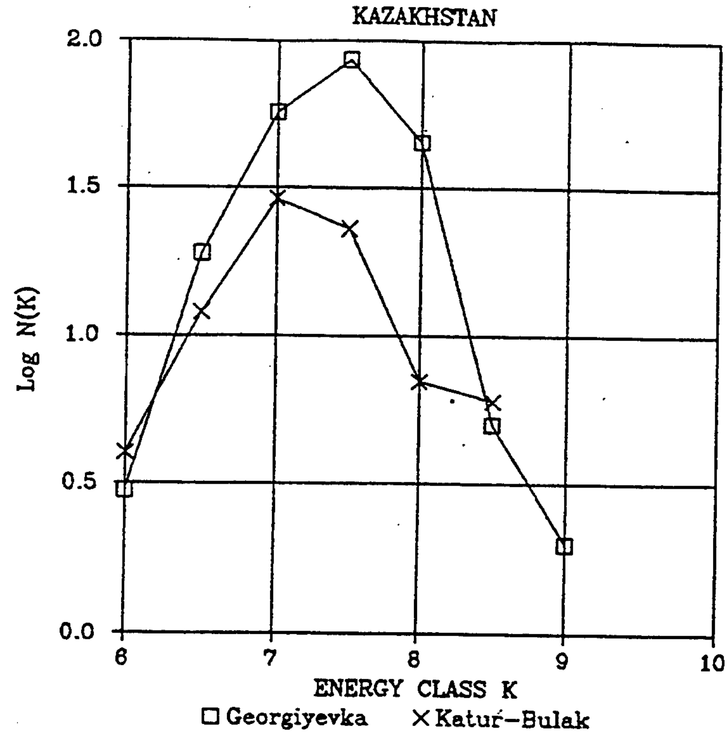

Figure 16.5. The recurrence curve of mine/quarry blasts vs. energy class K for two mines/quarries in Southern Kazakhstan: Georgievka and Katur-Bulak. The slope of the curve for Georgievka is −1.3 (corresponding to −3 on a magnitude scale, i.e. very steep).

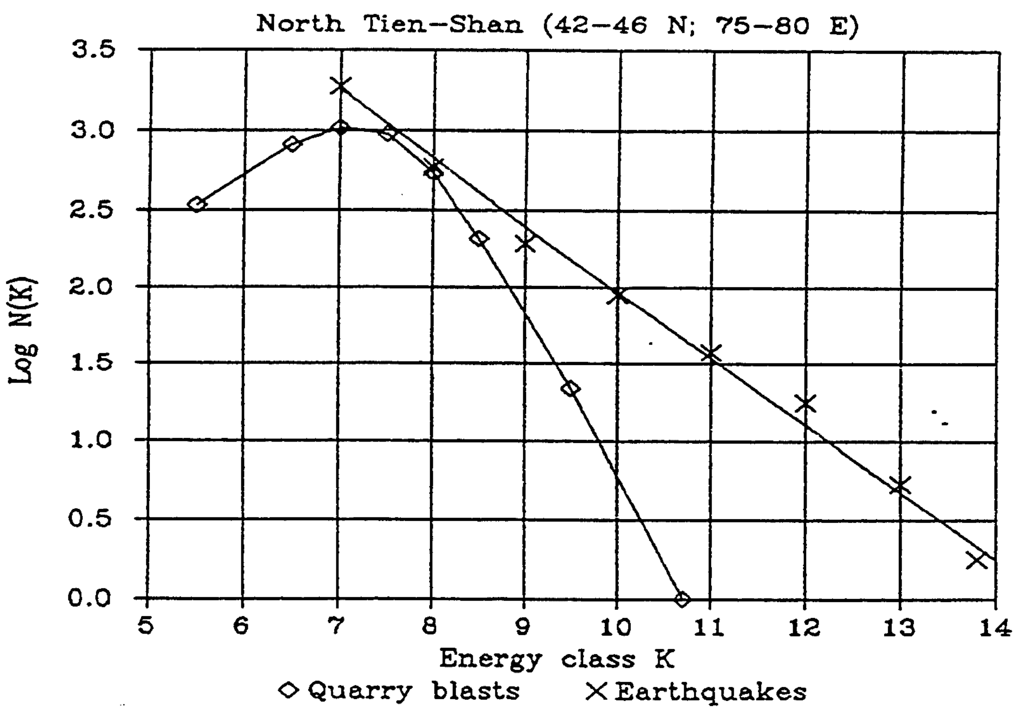

Figure 16.6. Comparison of recurrence curve (vs. K) of earthquakes and chemical explosions for the same region — Northern Tien Shan. The two are very different in slope at the higher K values.

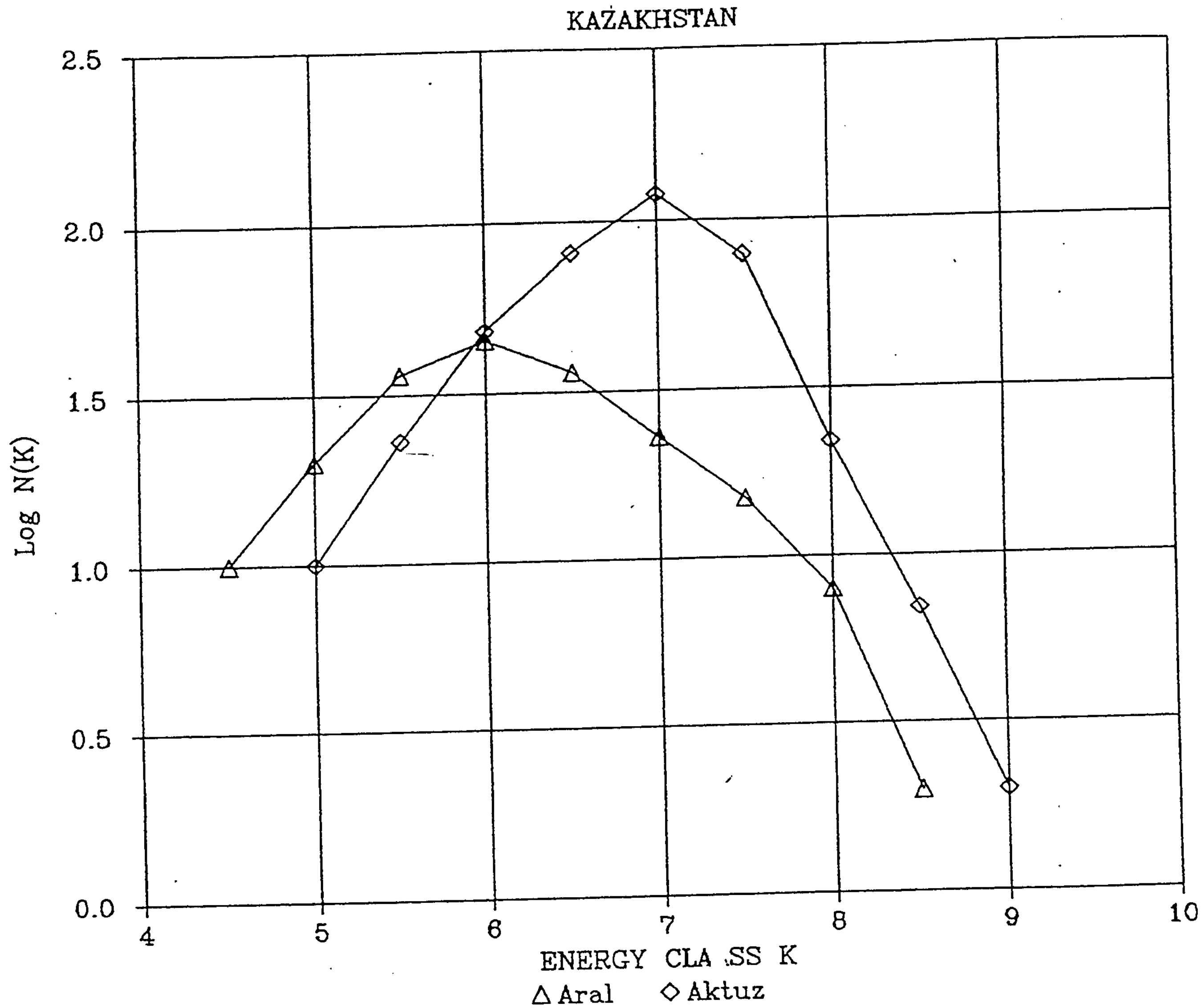

Figure 16.7. The recurrence curve of blasts vs. energy class K for two different mines/quarries: Aral and Akuz (1988 – 1994). The slope is –1 (–2.3 on a magnitude scale, i.e. very steep).

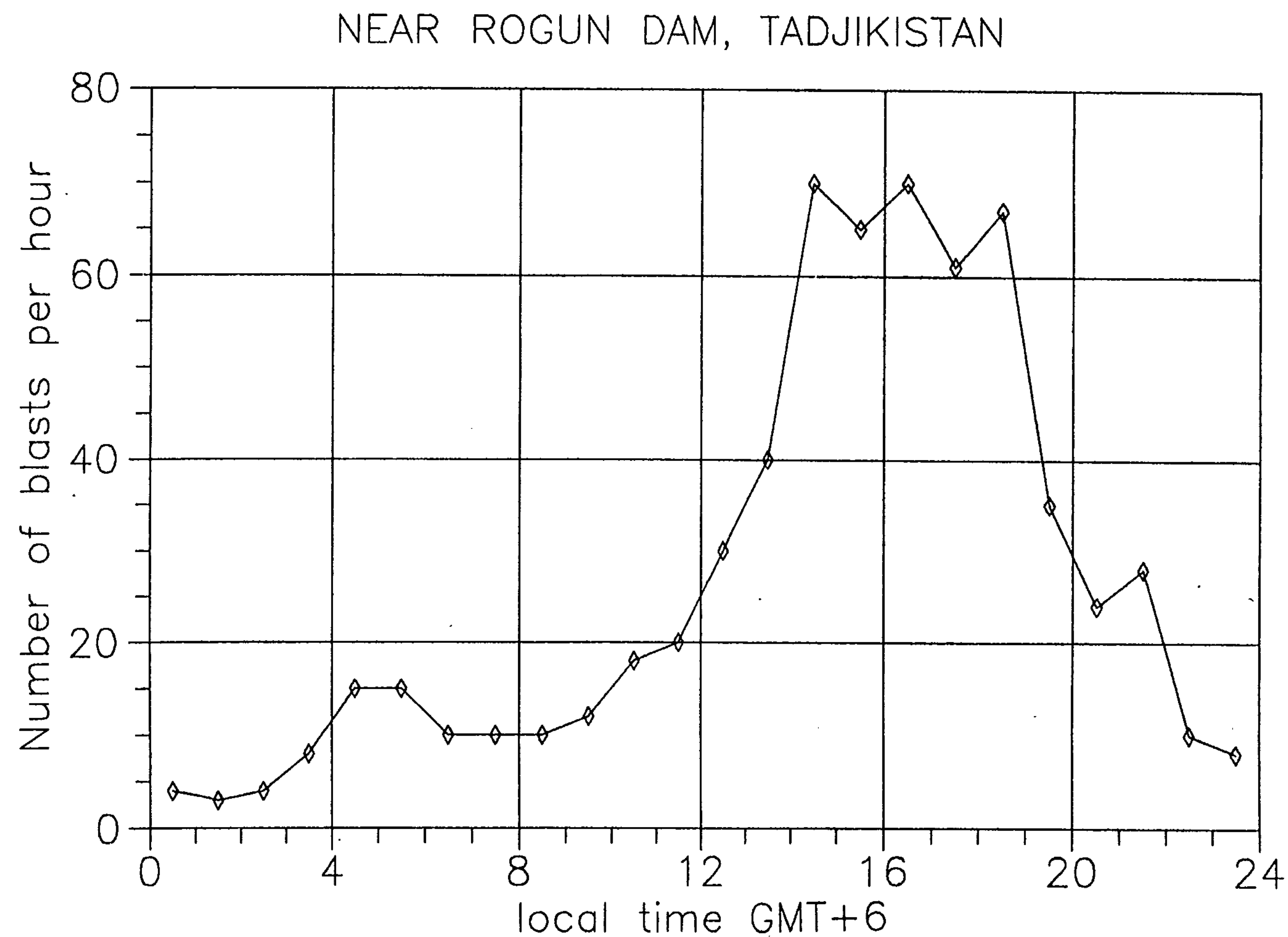

Figure 17.1. Distribution of seismic events vs. local time-of-day (GMT + 6) in Tadjikistan, for 50 km around the Rogun dam (38.7°N, 70.15°E) during a period of special observation (Feb 1989 – Aug 1991). Data from Godzikovskaya (1995). The peak indicates that most of these events are chemical explosions.

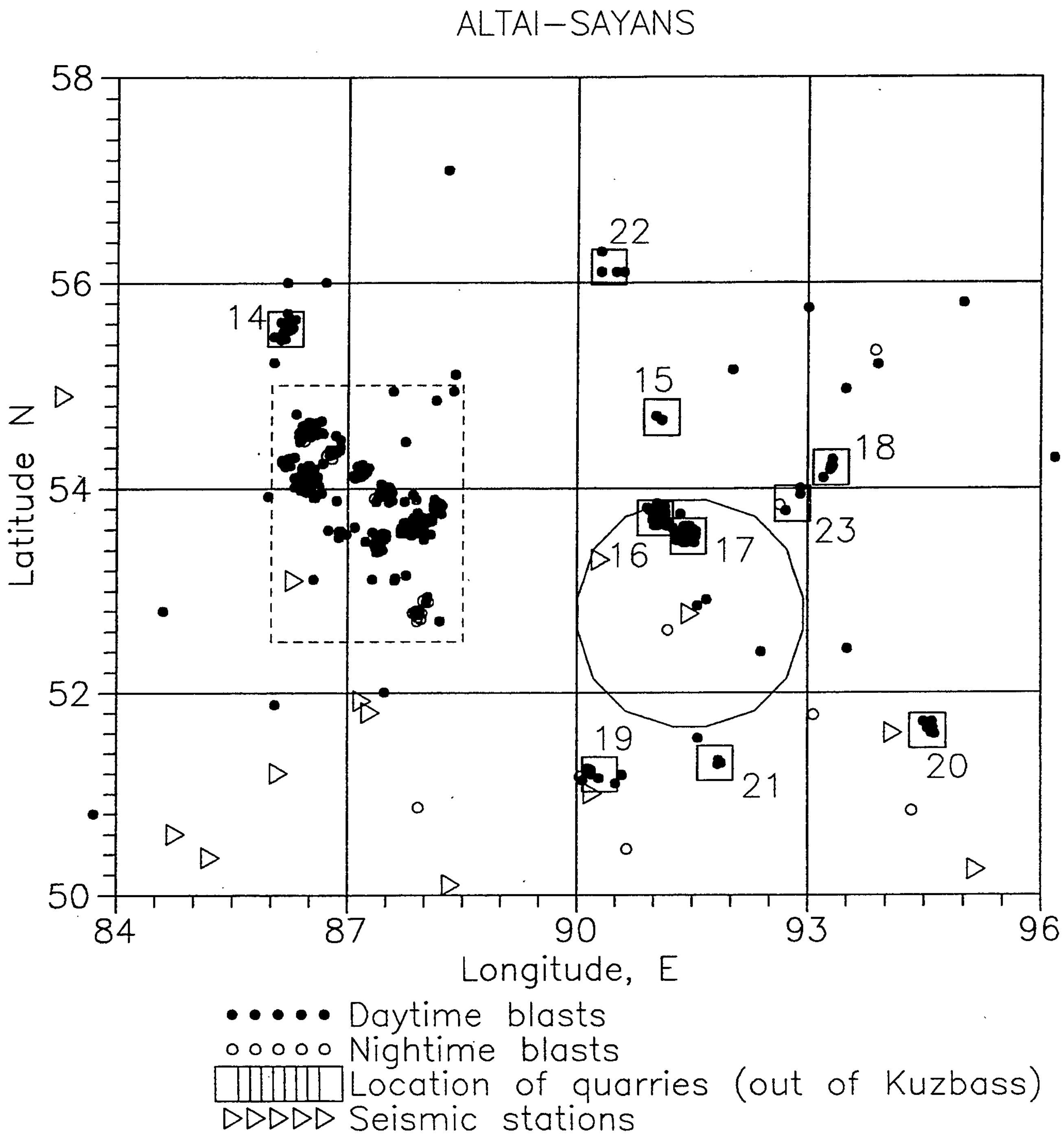

Figure 18.1. Map of 1064 blast locations in the Altai-Sayan region for years 1989 – 1993. Data from A. Filina (personal communication). Mine numbers correspond to Table 18.1. By using S – P times, more than 343 blasts recorded during 1991 – 1993 are known to have been close to the Cheremushki station (see Table 18.3: this set includes large blasts from mines #16 and 17). The dashed rectangle outlines the Kuzbass industrial zone (see also Fig. 18.2).

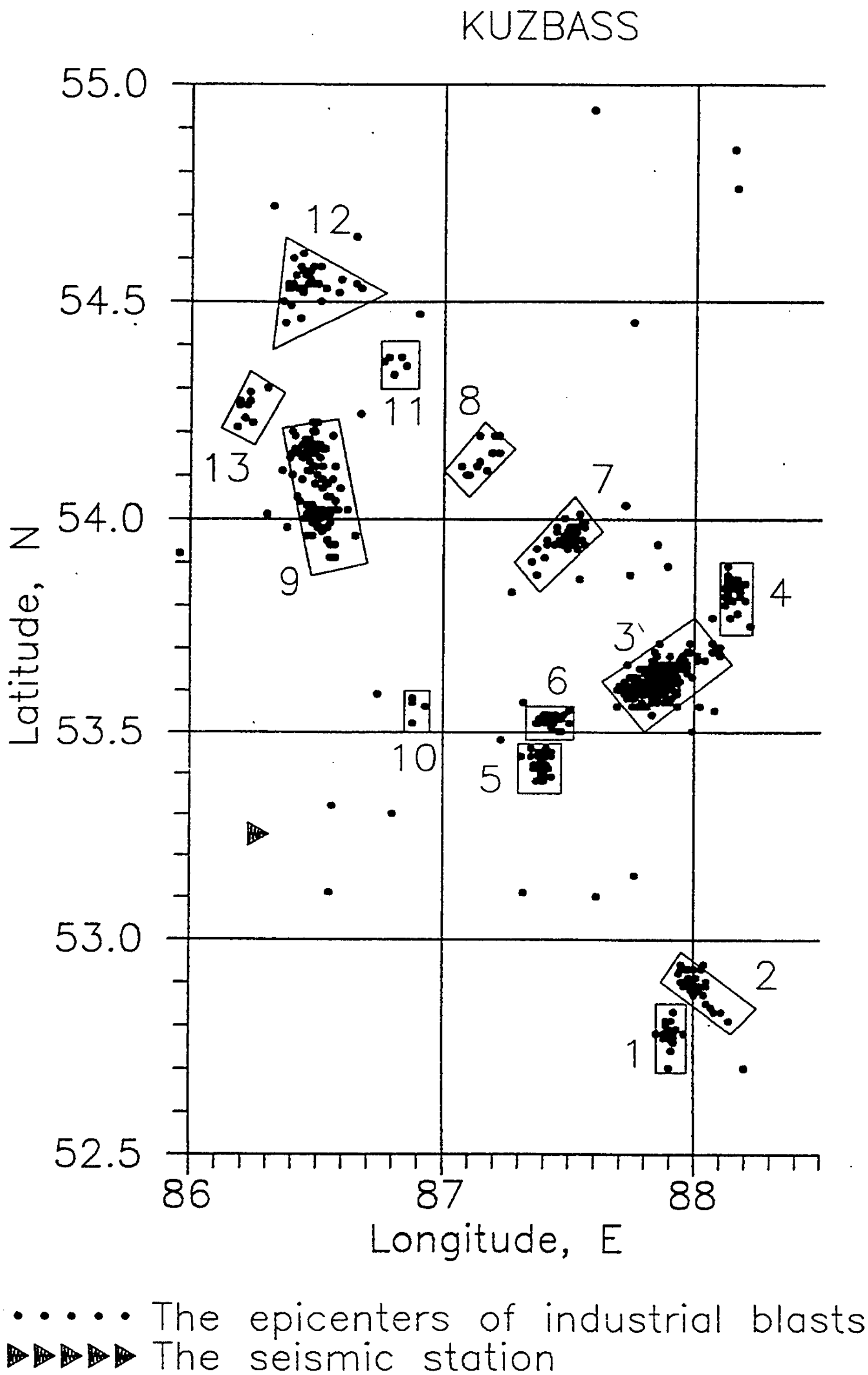

Figure 18.2. The location of mines/quarries and seismic epicenters during 1989 – 1993 in the Kuzbass region of Altai-Sayan. The mine/quarry areas are outlined, and numbered corresponding to entries in Table 18.1.

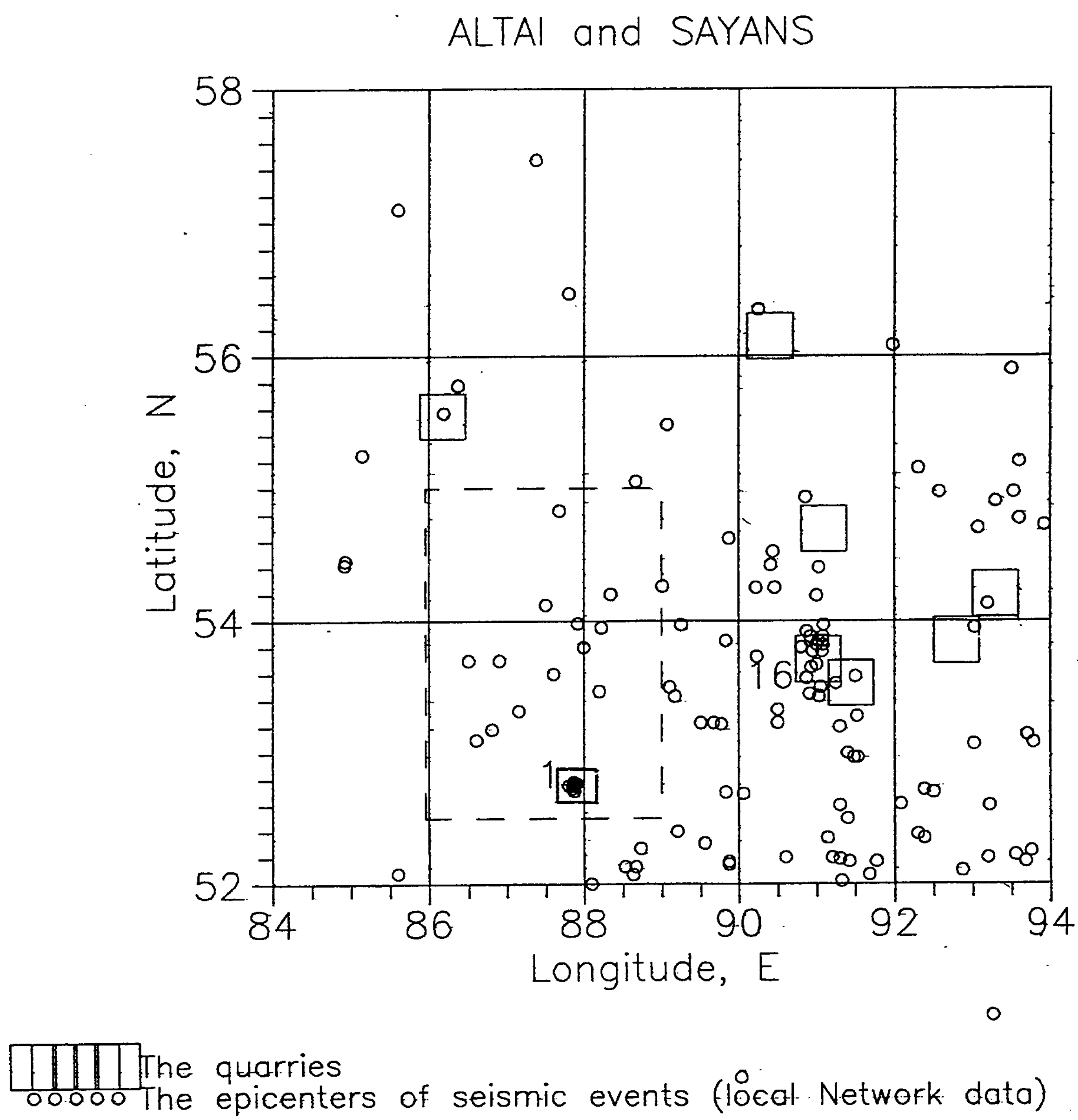

Figure 18.3. Epicenters that were believed to be natural seismicity in the Altai-Sayan region for years 1962 – 1990. Note however that there are two clusters of epicenters, located at the Abakansky mine (#16) and the Tashtagol mine (#1). These events are probably blasts.

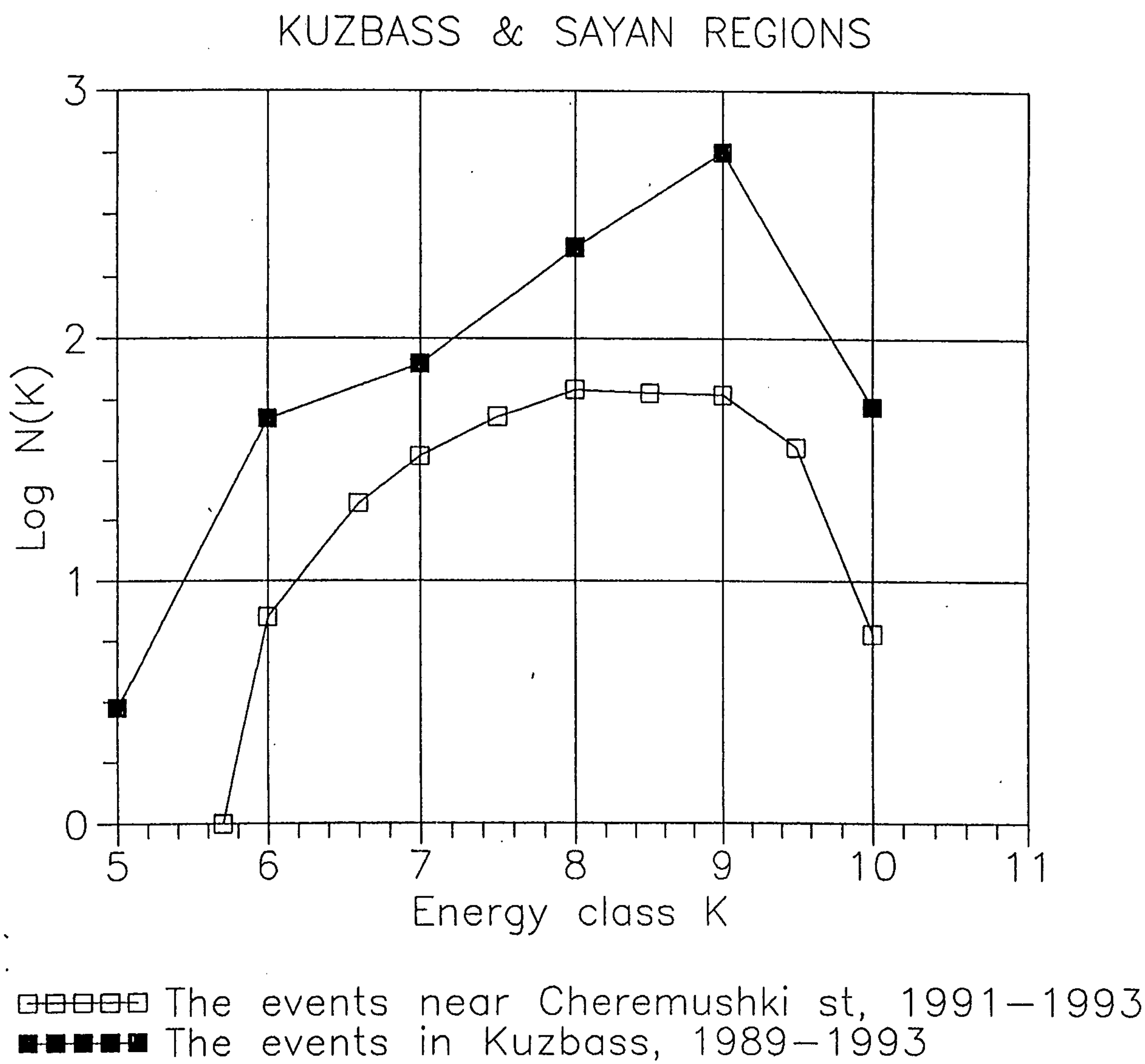

Figure 18.4. The recurrence curve of chemical explosions vs. K value, for Kuzbass events and events near the Cheremushki station. The high slope (at high K values) is much steeper than for earthquakes. Note the occurrence of a significant number of events with K = 10. Such events can often be detected teleseismically.

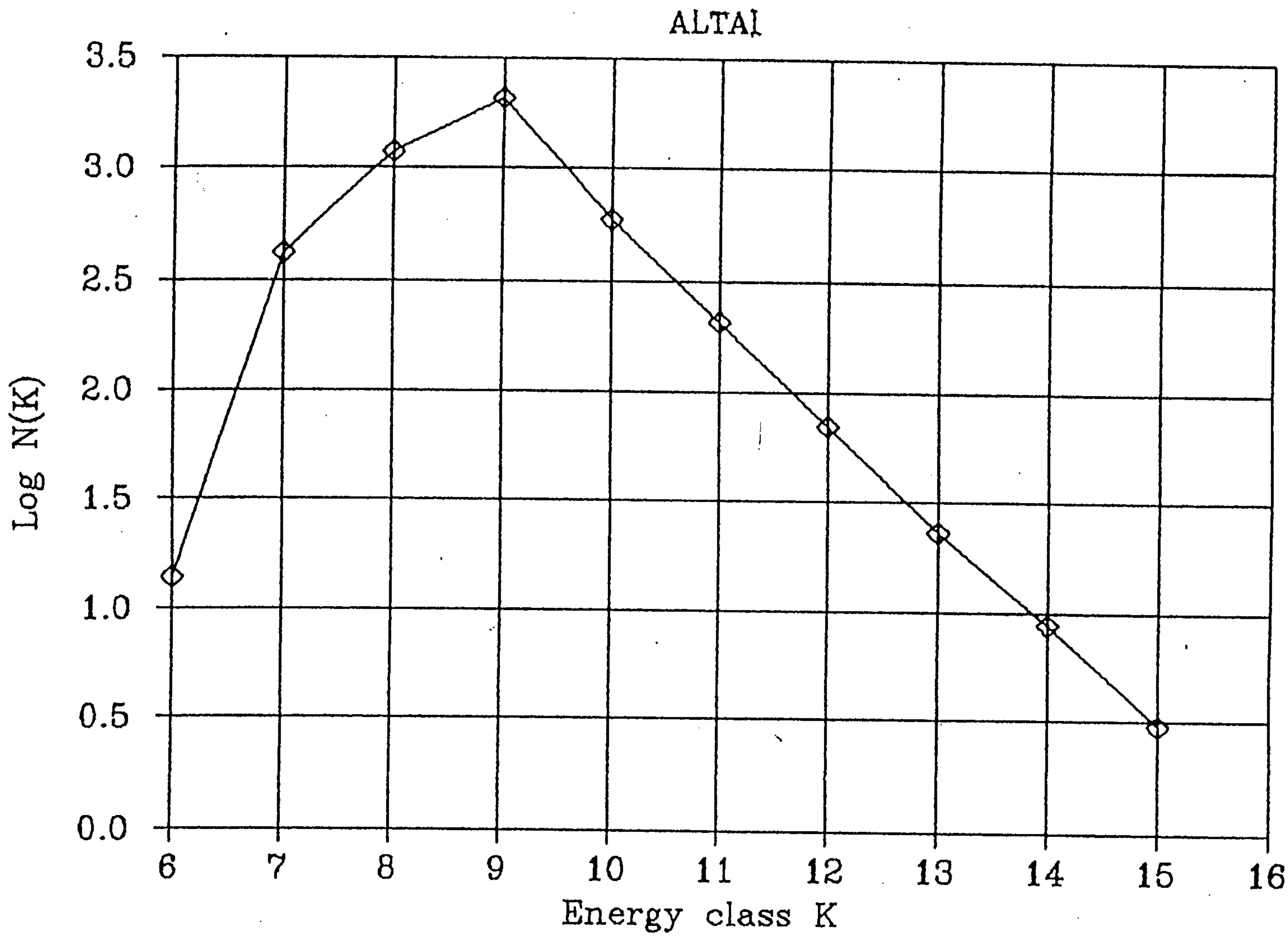

Figure 18.5. The recurrence curve of earthquakes vs. K value for the Altai region (80-100°N, 42-50°E) during 1962 – 1987. The slope is –0.46 (corresponding to –1 in a magnitude classification).

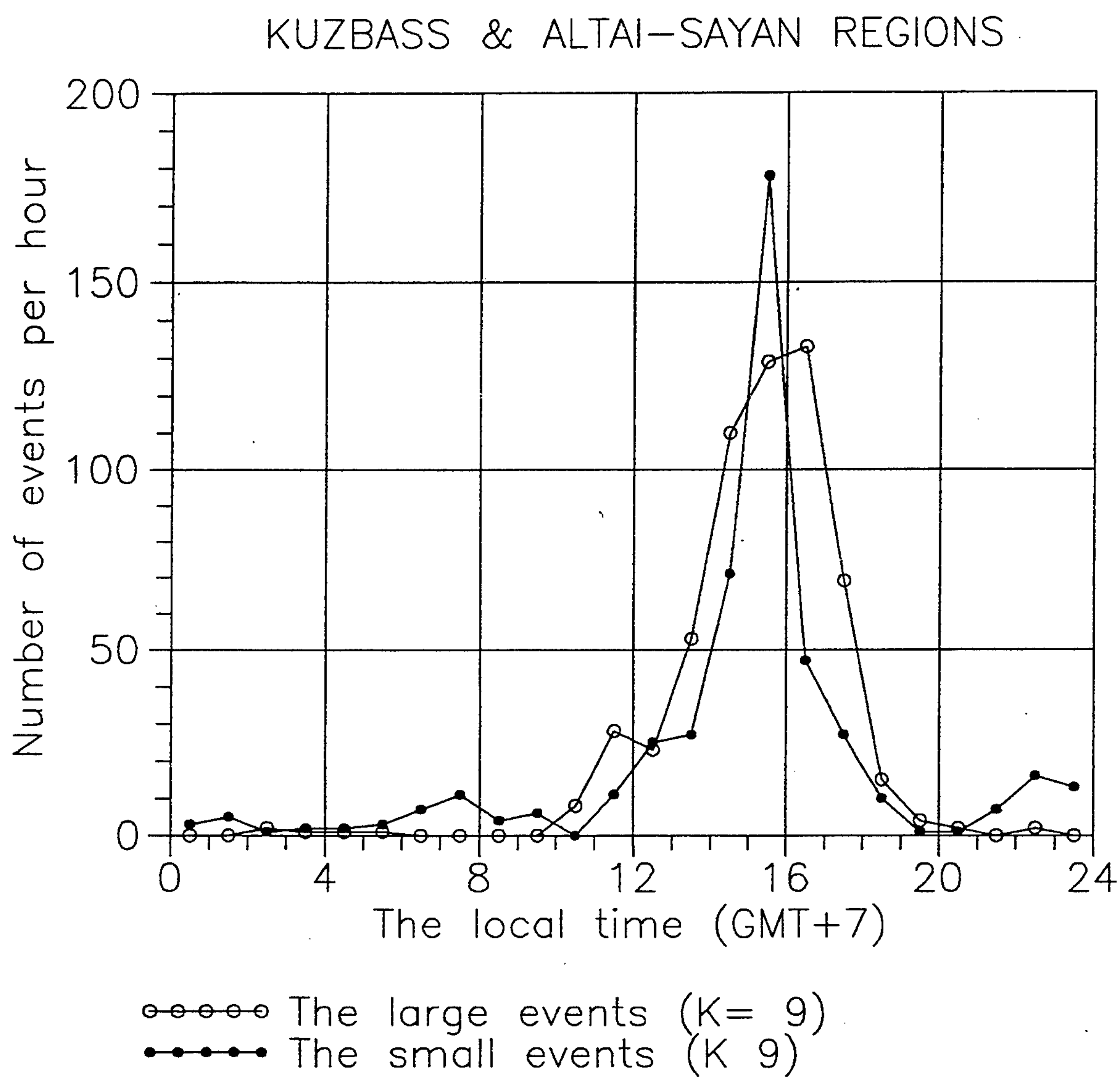

Figure 18.6. Distribution of blasts vs. local time-of-day (GMT + 7) for the Kuzbass-Altai-Sayan region during 1989 – 1993. Data are from A. Filina and A. Godzikovskaya (personal communication). Time-of-event is an excellent discriminant.

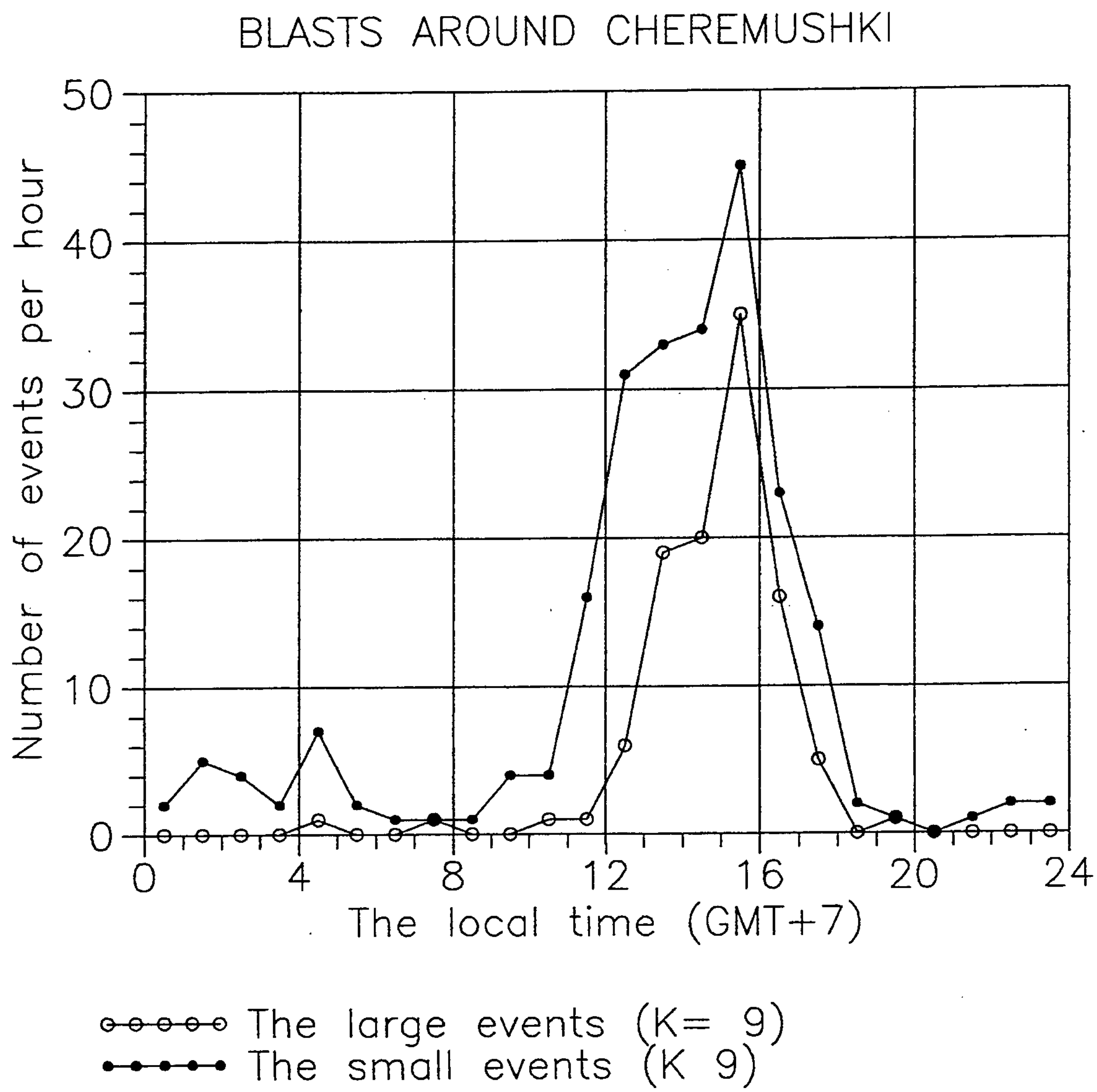

Figure 18.7. Distribution of blasts vs. local time-of-day (GMT + 7) for the nearby events recorded by the Cheremushki station during 1989 – 1993. Data from A. Filina and A. Godzikovskaya (personal communication).

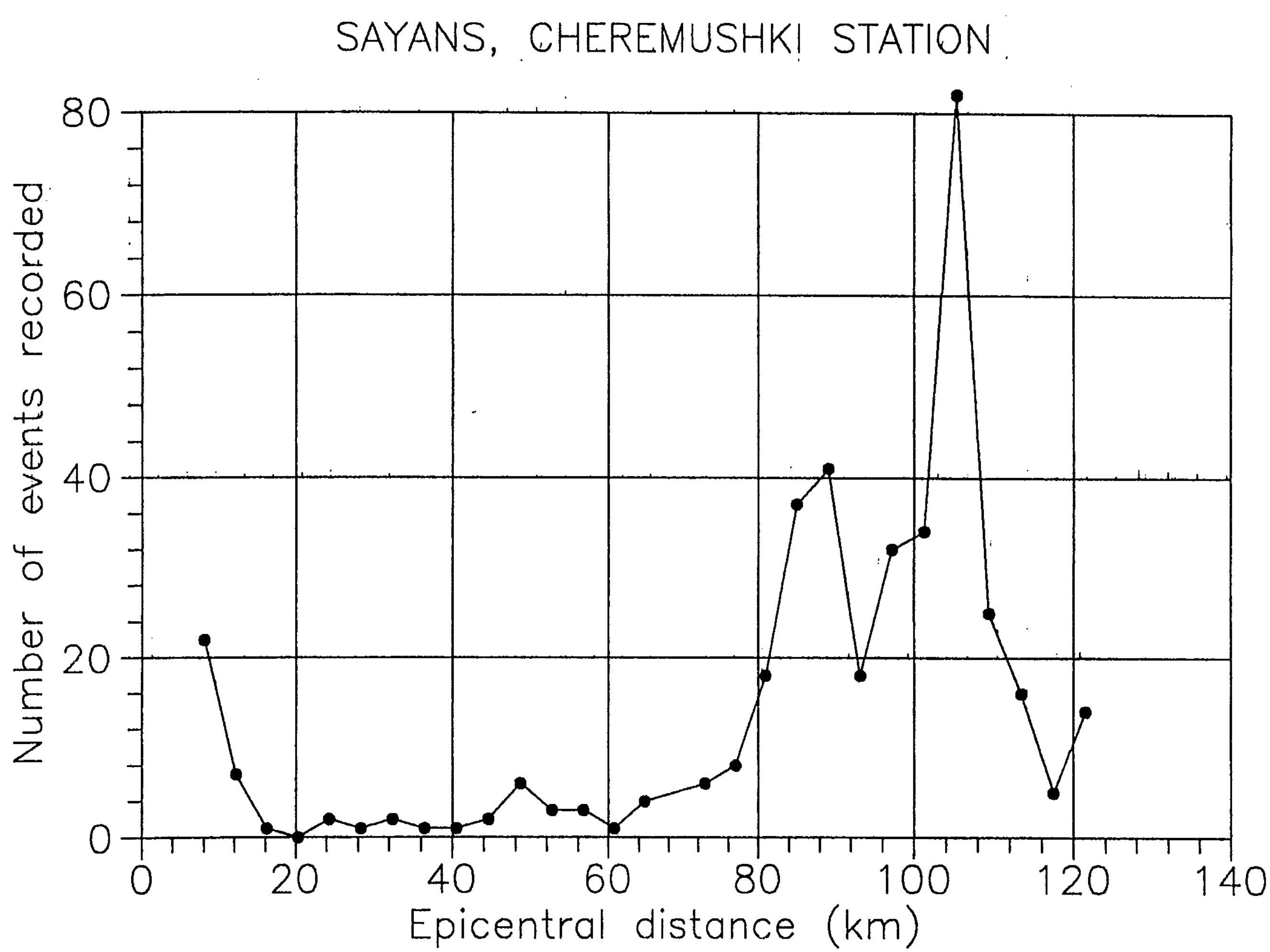

Figure 18.8. The distribution of epicentral distances, for events recorded by the Cheremushki seismographic station. Peaks between 85 and 110 km correspond to the distance from the Abakansky (#16 and #17) and Abasinsky (#23) mines.

THE MAP OF QUARRIES IN BAIKAL REGION

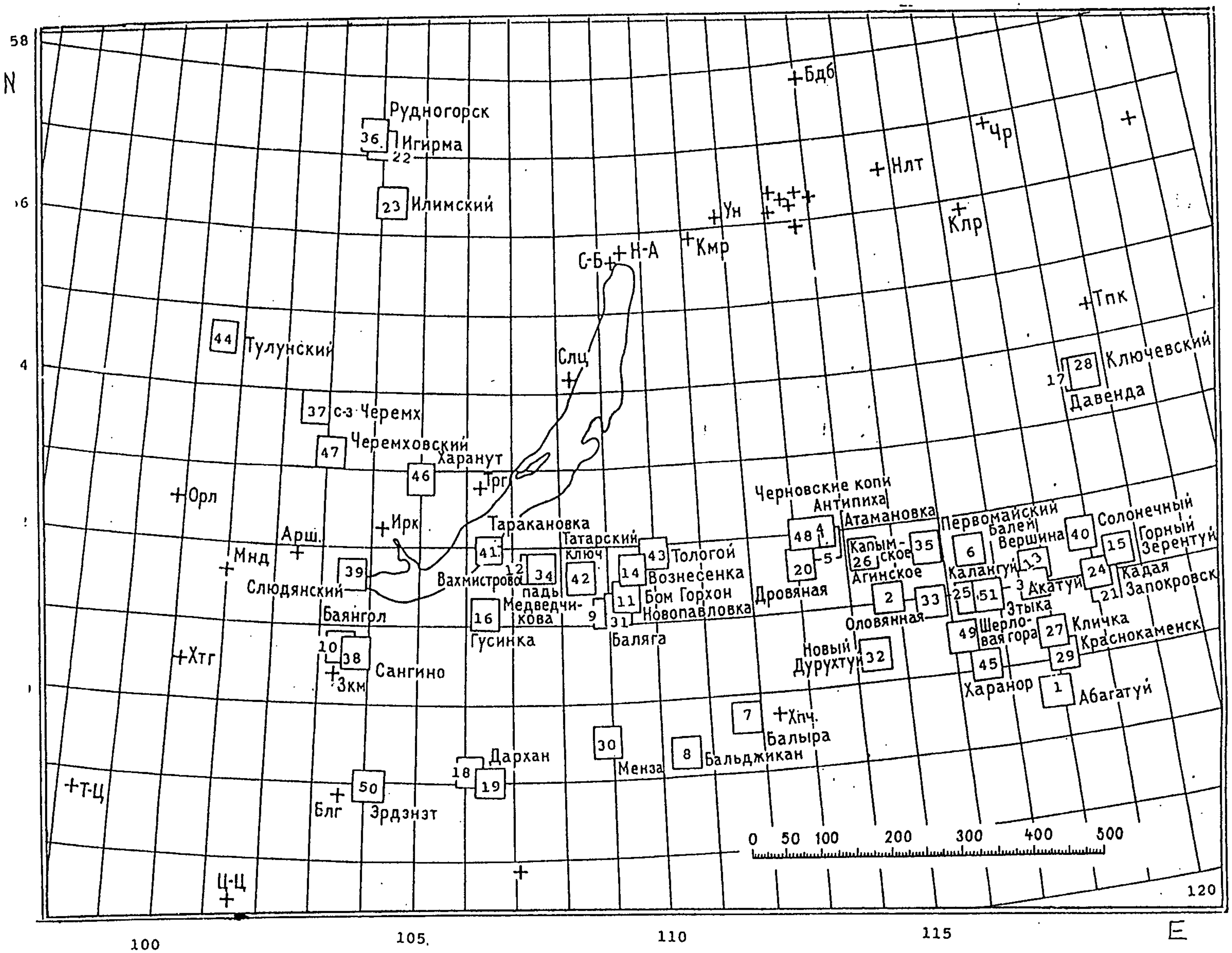

Figure 19.1. A map of mines and seismographic stations (crosses) in the Baikal region.

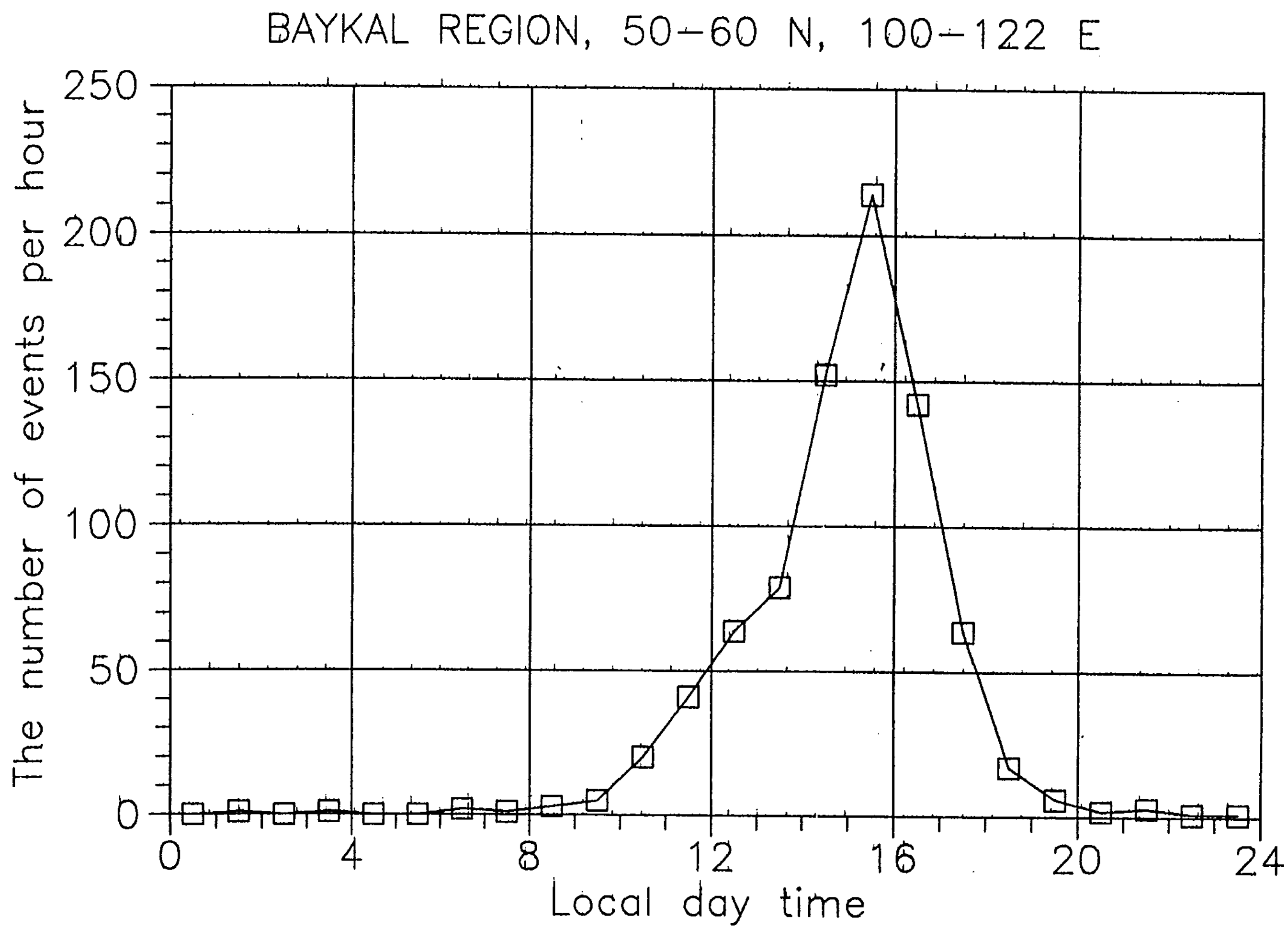

Figure 19.2. Distribution of blasts vs. local time-of-day (GMT + 8) for mines/quarries in the Baikal region. Data are from the blast bulletin of L. Delistsin (personal communication), for the periods Jul – Oct 1991 and Jun – Oct 1992.

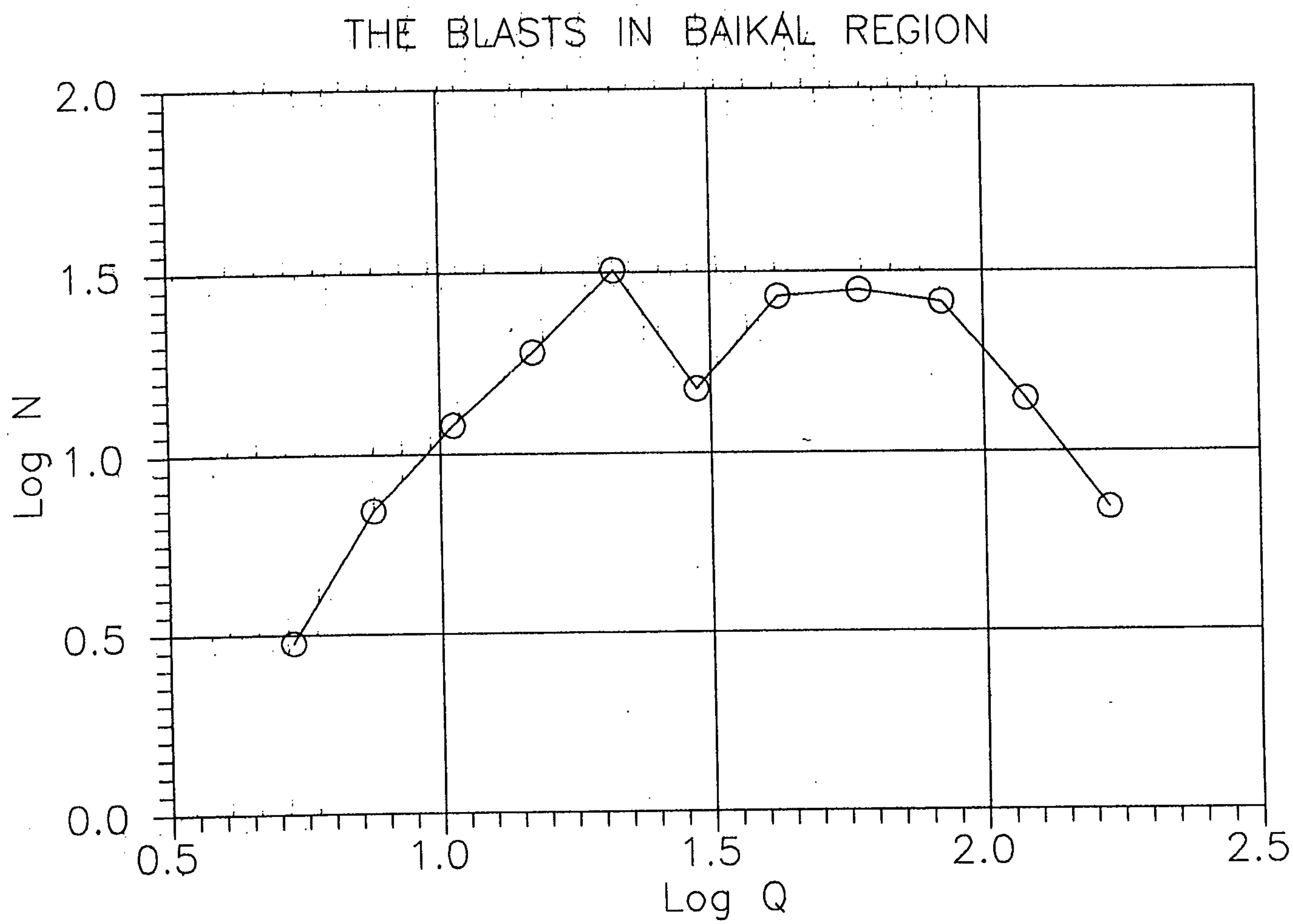

Figure 19.3. Distribution of blasts vs. yield Q (tons), for the Baikal region. Yield ranges up to about 200 tons.

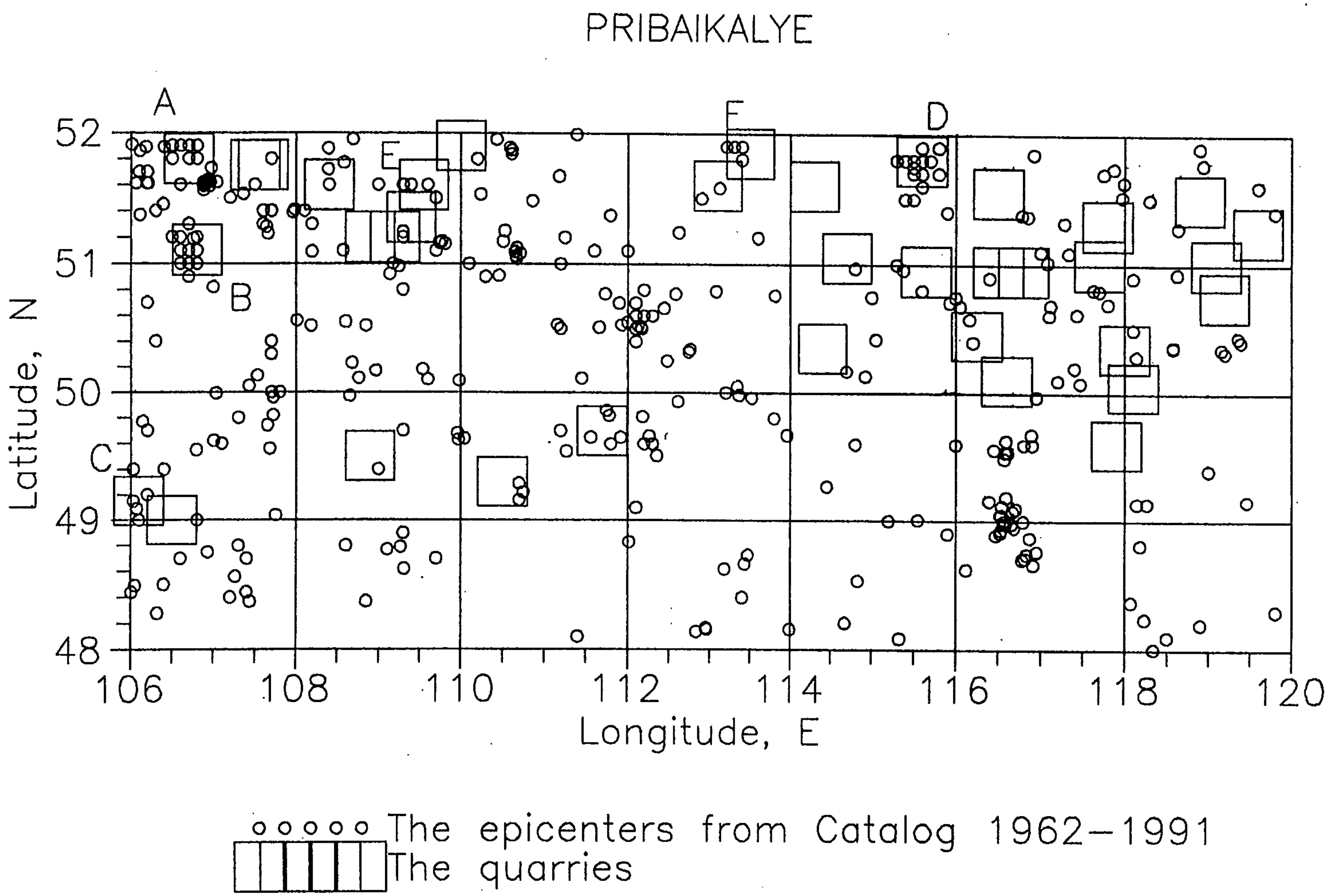

Figure 19.4. Map of seismic events in the Pribaikalye region, taken from the ESSN catalogs for 1962 – 1991. Note clusters of epicenters, coinciding with some mine/quarry locations: A — Tarakanovka; B — Goosinka; C — Darkhan; D — Pervomaisky; E — Voznesenka; and F — Atamanovka.

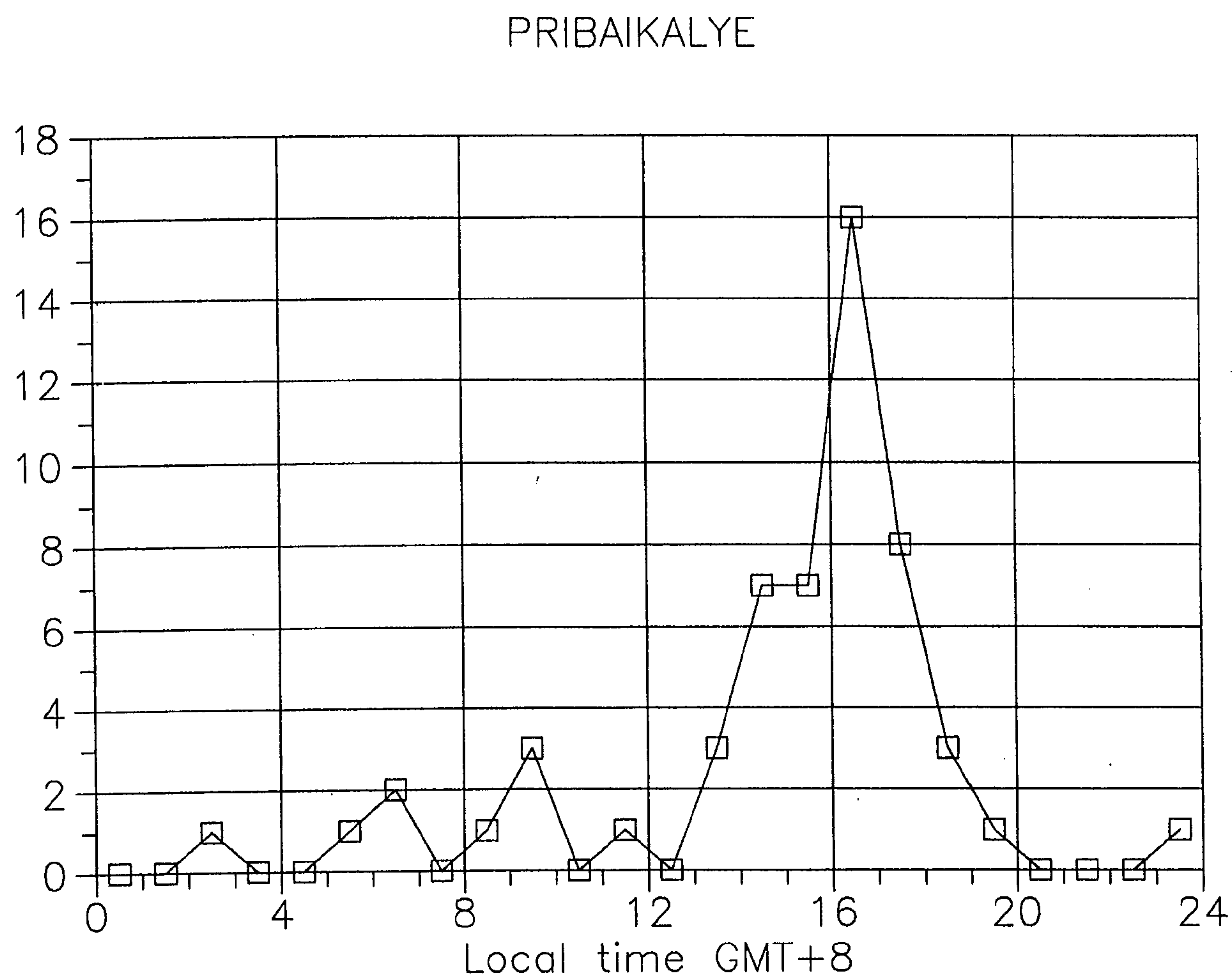

Figure 19.5. Distribution of seismic events vs. local time-of-day (GMT + 8), for epicenters in the Pribaikalye areas A to F of Figure 19.4. Most of these events are explosions, carried out at the end of the workday.

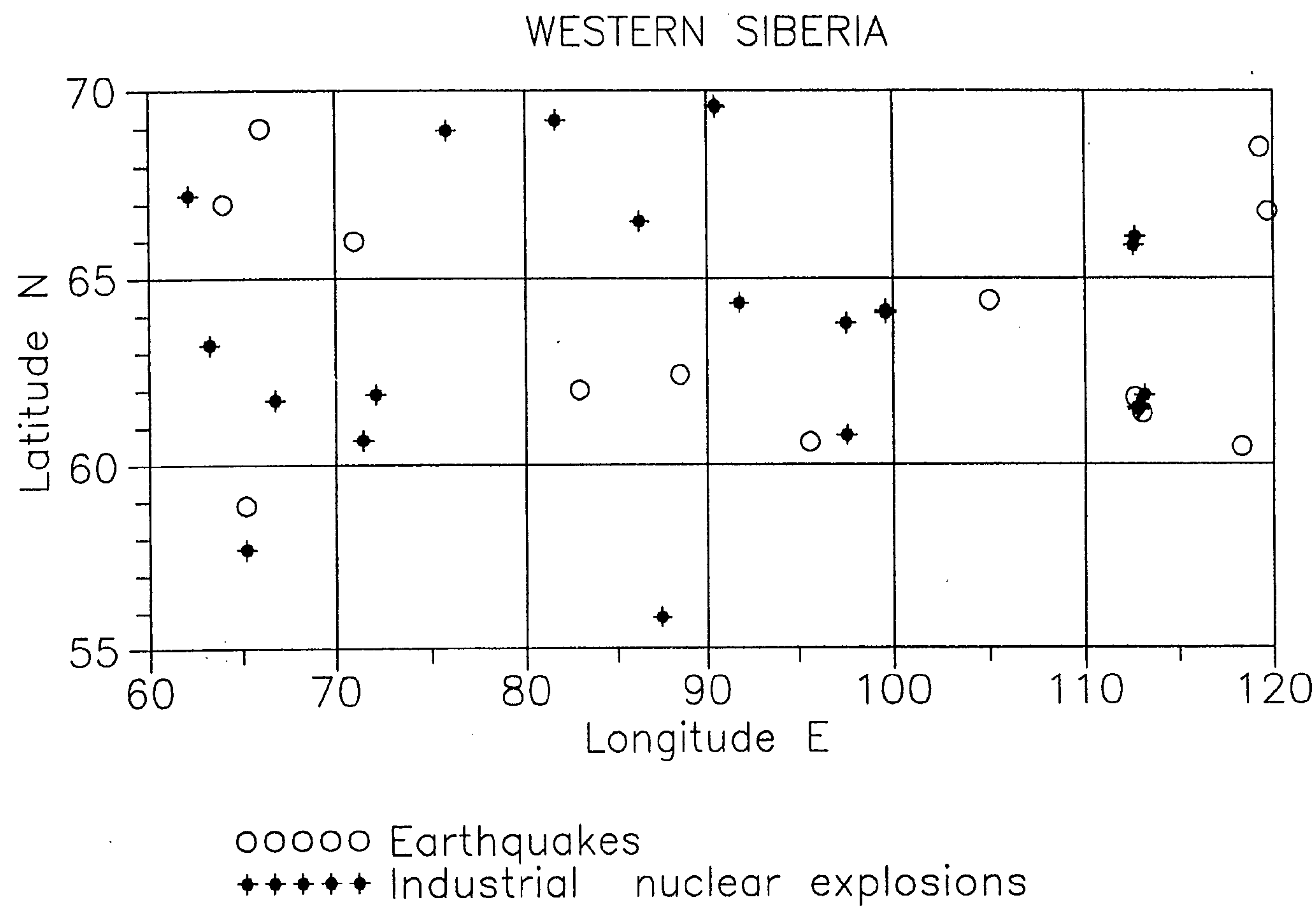

Figure 20.1. Map of seismic epicenters in the Western Siberian region. Locations taken from ISC, NORSAR, and OBN catalogs, for the years 1964 – 1995.

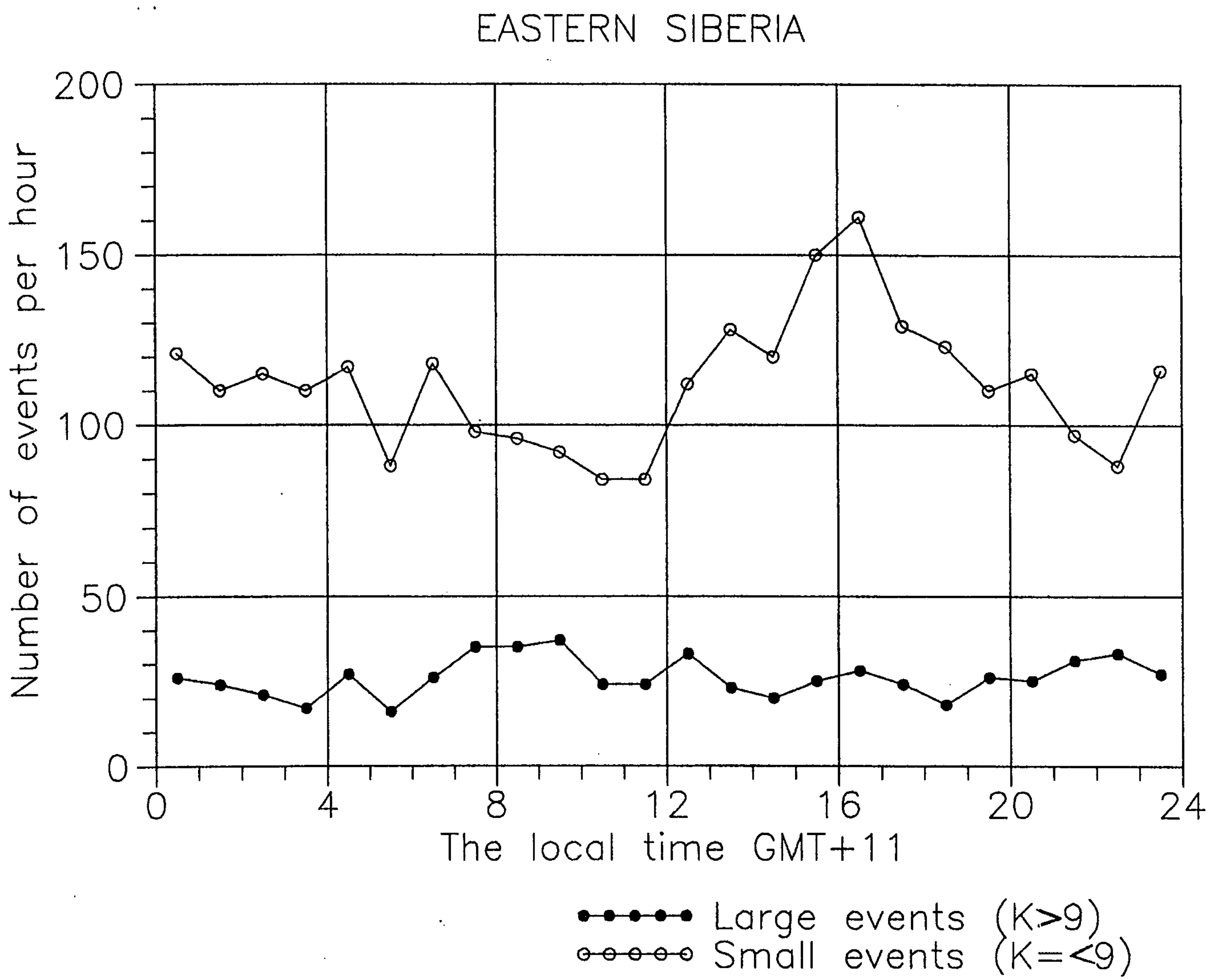

Figure 21.1. Distribution of small (K ≤ 9) and large (9 < K) seismic events, vs. local time-of-day (GMT + 11) for the Eastern Siberia region. Some of the small events would appear to be blasts, but the large events must almost all (if not all) be earthquakes.

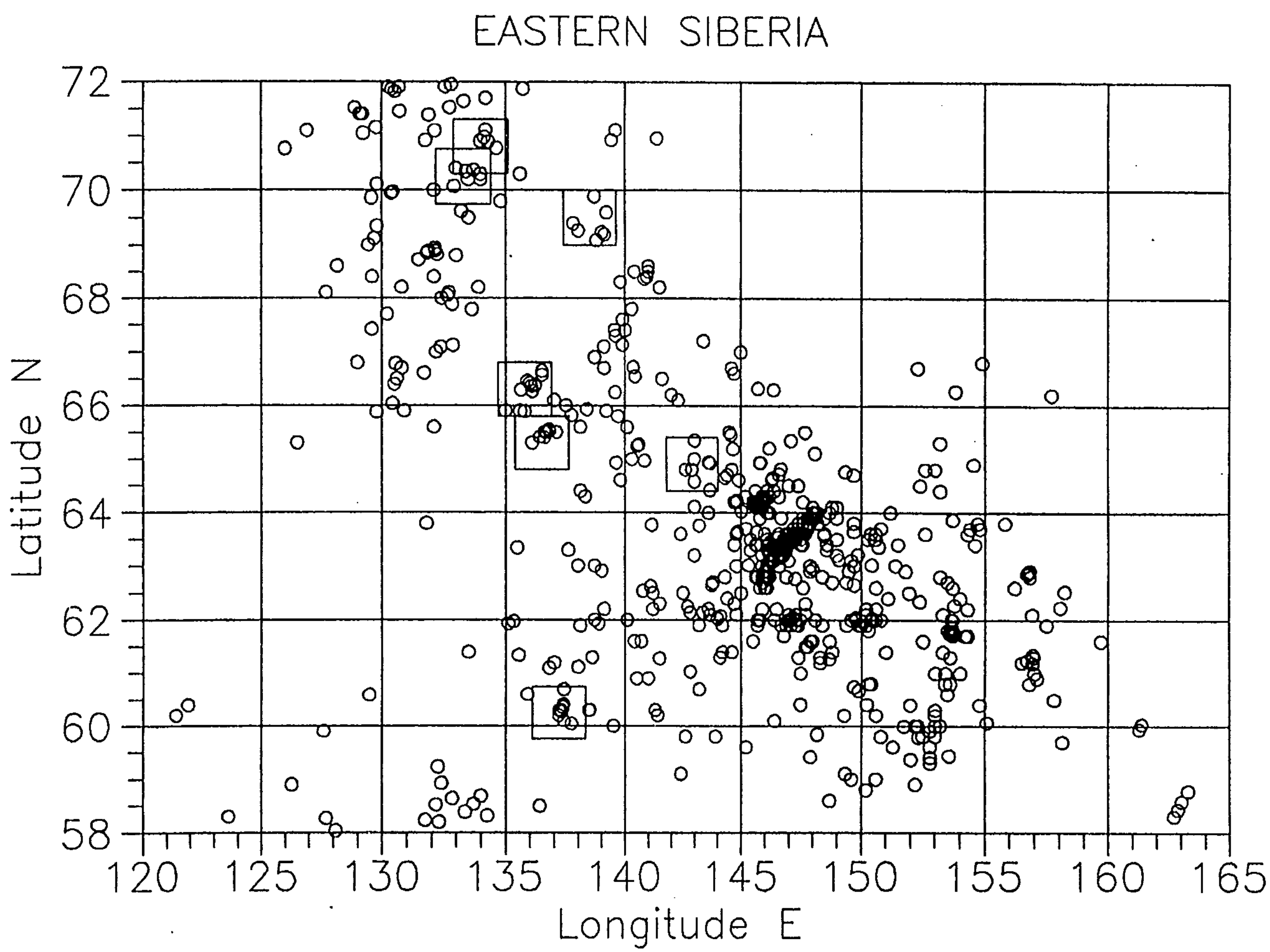

Figure 21.2. Epicenter map of small (K < 10) seismic events in Eastern Siberia occurring during 1200 – 1700 hours local time. Data are from ESSN, 1962 – 1990. The squares mark clusters of events that, from their spatial and temporal occurrence, are probably blasts.

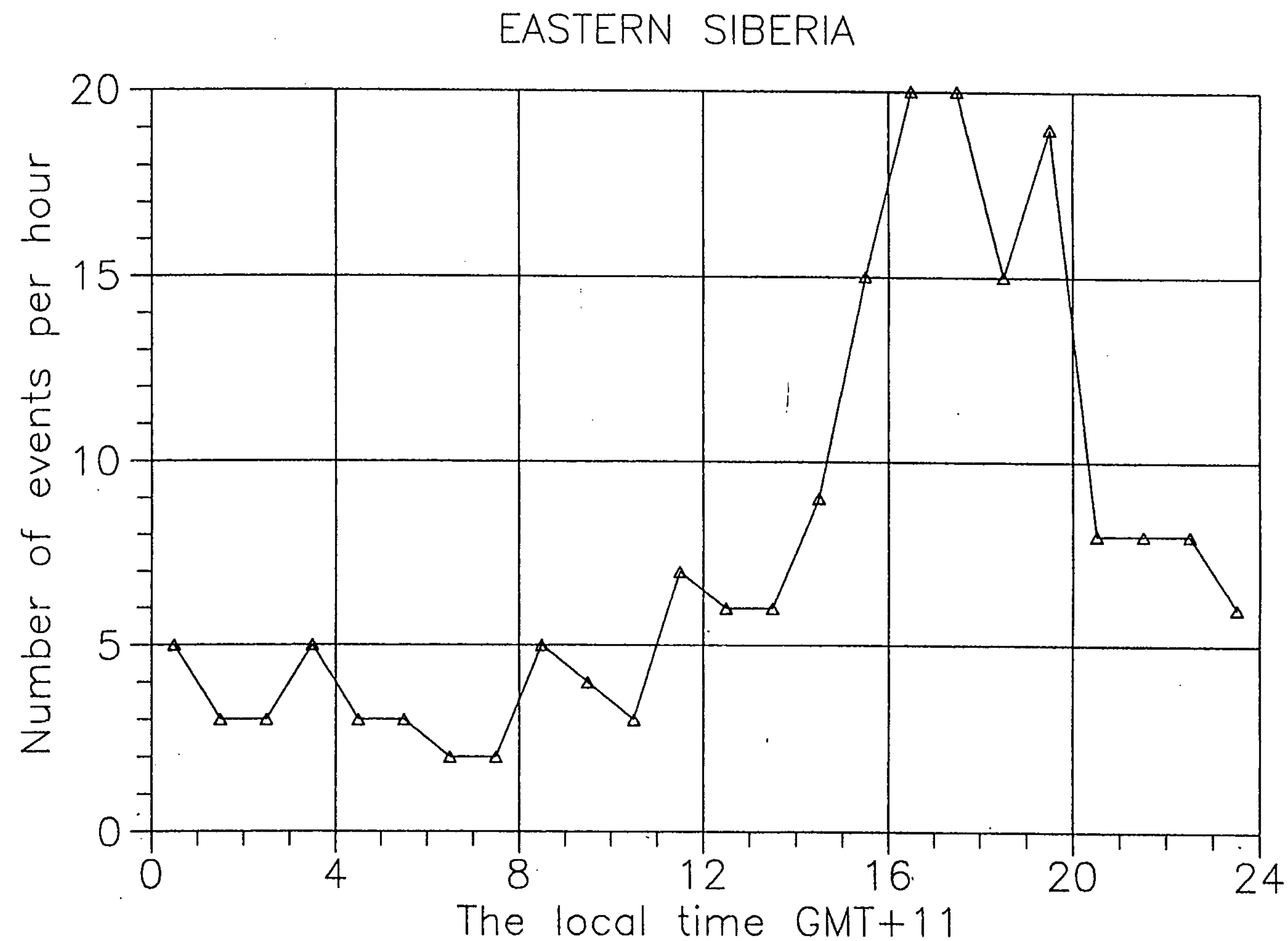

Figure 21.3. Distribution of small seismic events ($K \leq 9$) vs. local time-of-day (GMT + 11), within the areas marked as A, B, C, of Fig. 21.2. Data are taken mostly from ESSN for the years 1962 – 1990.

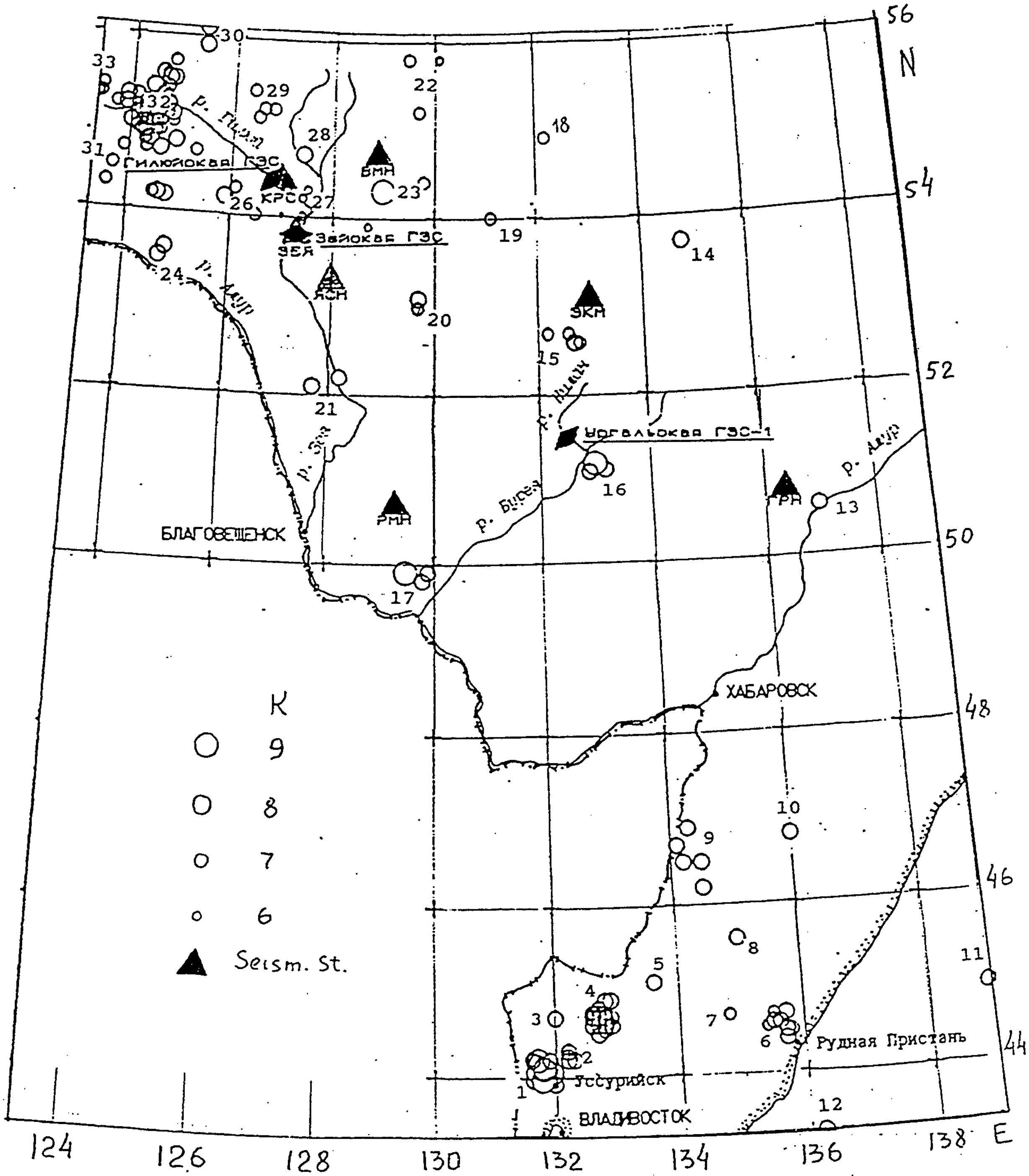

Figure 22.1. Map of industrial explosions (open circles) and seismographic stations (triangles) in the Russian Far East region (Primorye).

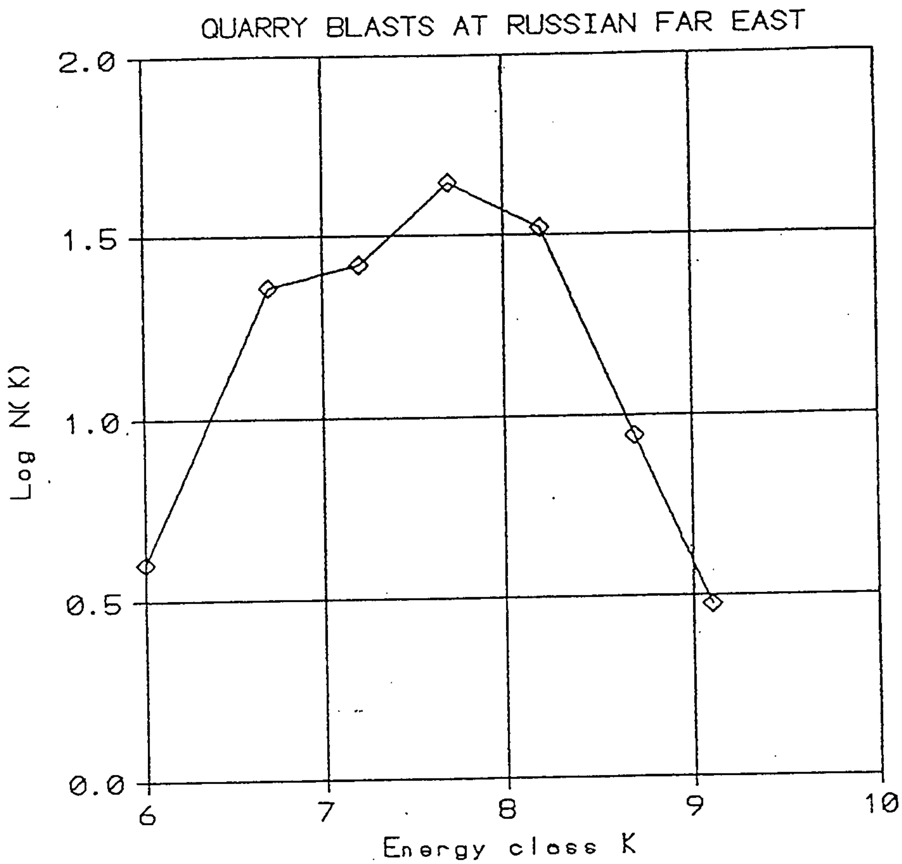

Figure 22.2. The recurrence curve of industrial blasting in the Russian Far East region (44-56°N, 123-139°E) during years 1990 – 1991. The slope at higher K values is –1.15 (–2.5 in magnitude classification).

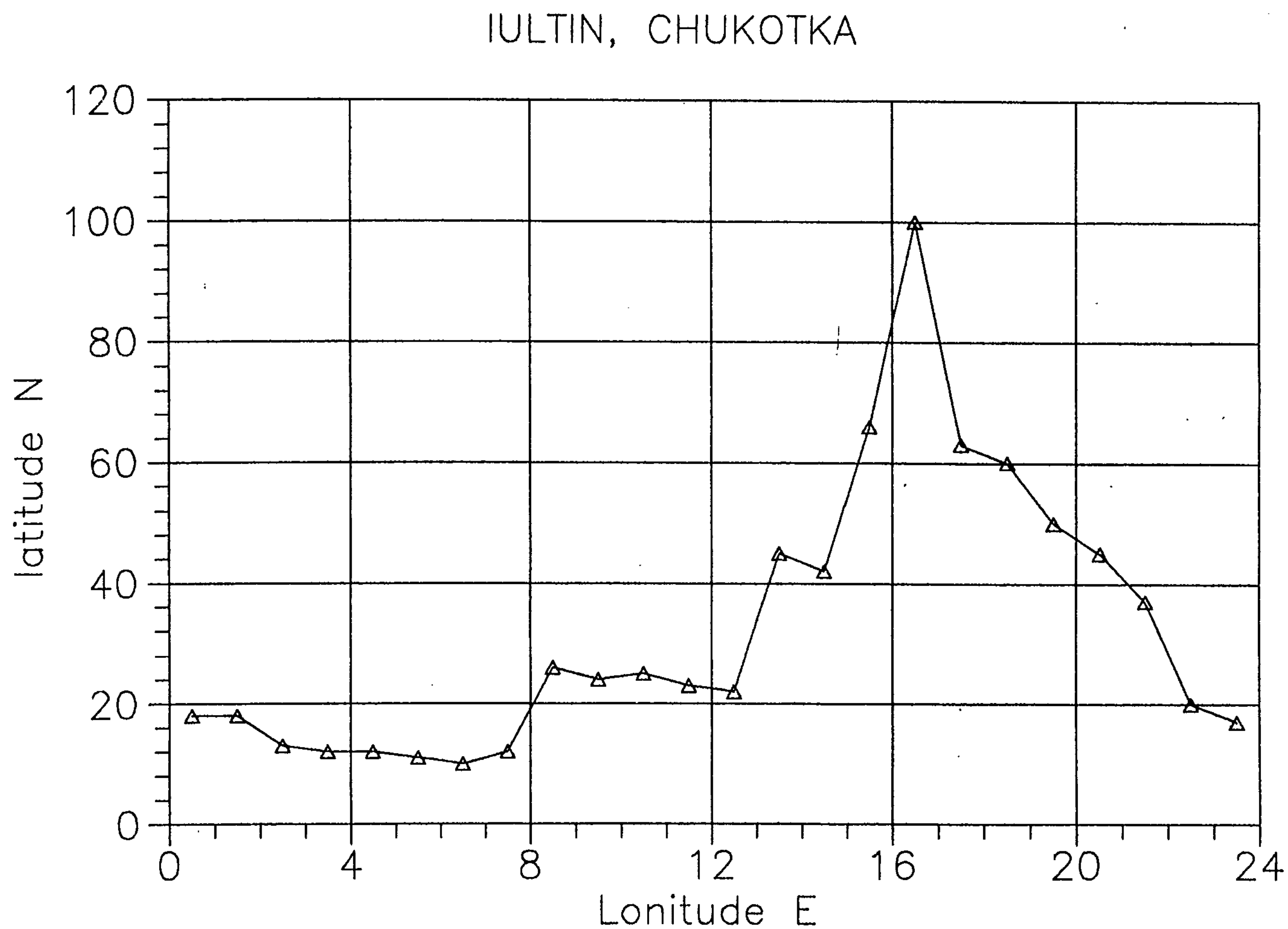

Figure 24.1. The distribution of seismic events vs. longitude East during years 1986 – 1989, as determined from data of the Iultin seismographic station located some 20 km from the Amguemskaya dam at (69°N, 177°E).

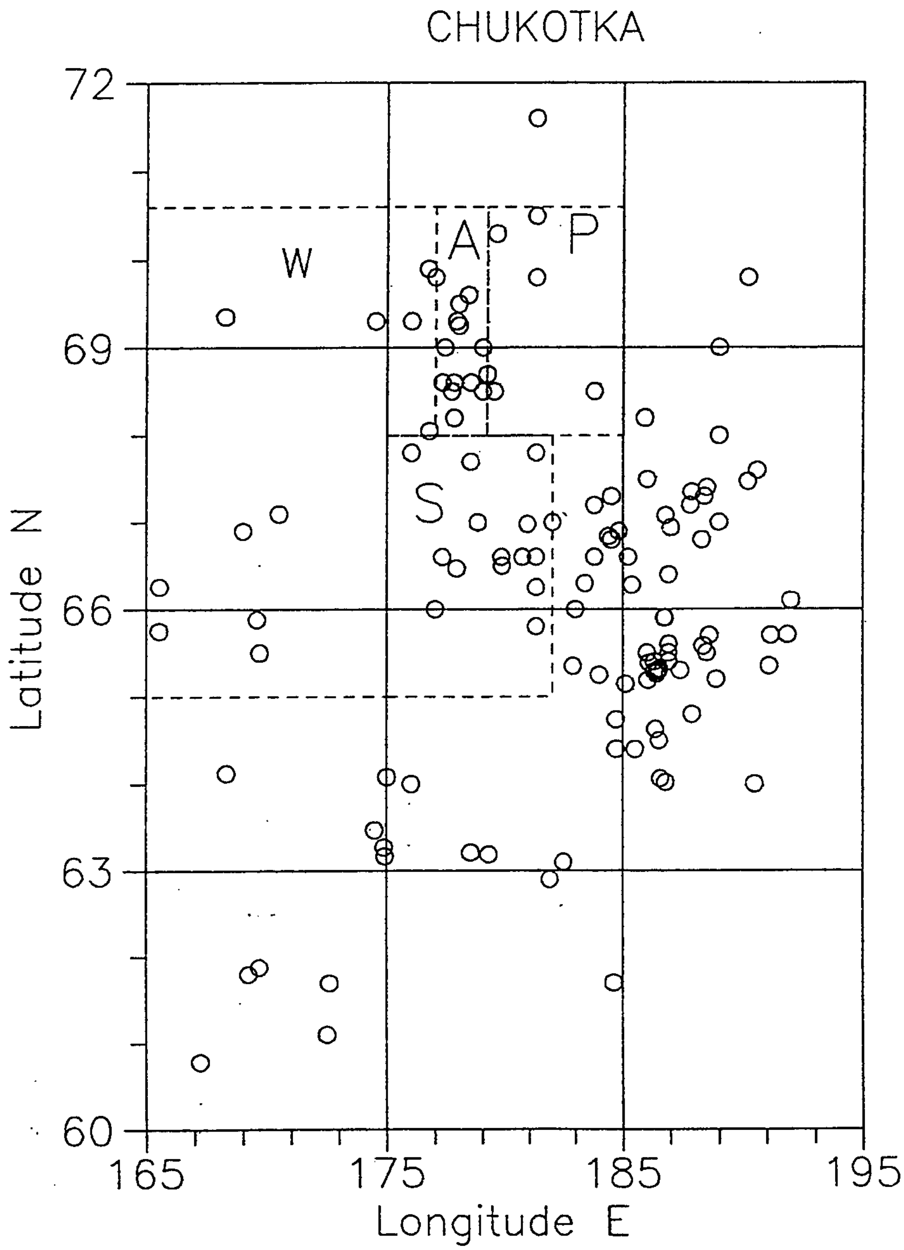

Figure 24.2. Distribution of seismic events (all with K ≤ 10) vs. local time-of-day (GMT + 13), in the Chukotka region (60-72°N, 165-195°E). Data from the ESSN catalogs for 1962 – 1990.

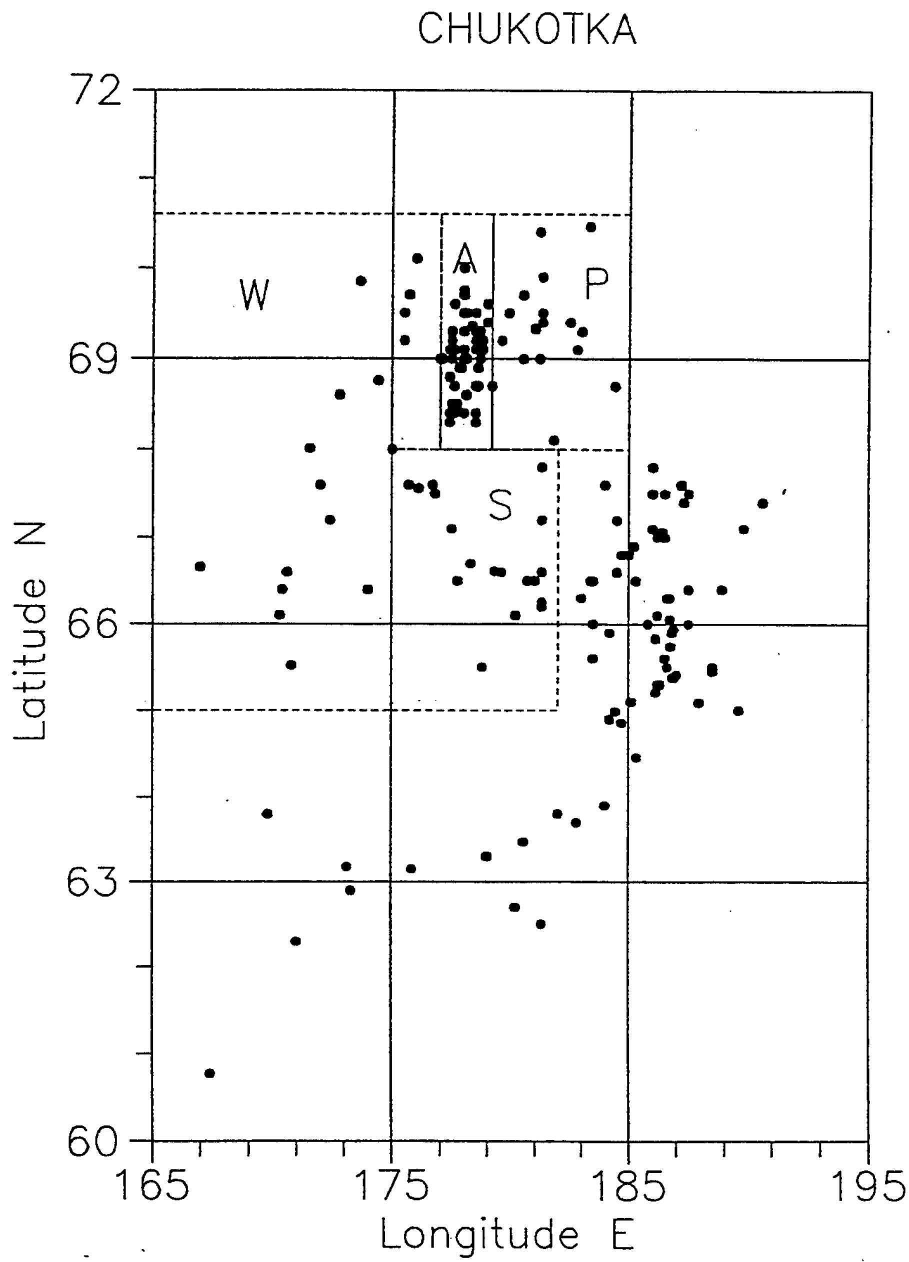

Figure 24.3. Map of epicenters of small (K ≤ 10) Chukotka events that occurred during the time of high blasting activity between 0700 and 1700 hours local time (see Fig. 24.2). Areas marked A, P, S, W are selected to test for seismicity that varies with time-of-day. Data are mostly from ESSN catalogs for 1962 – 1990.

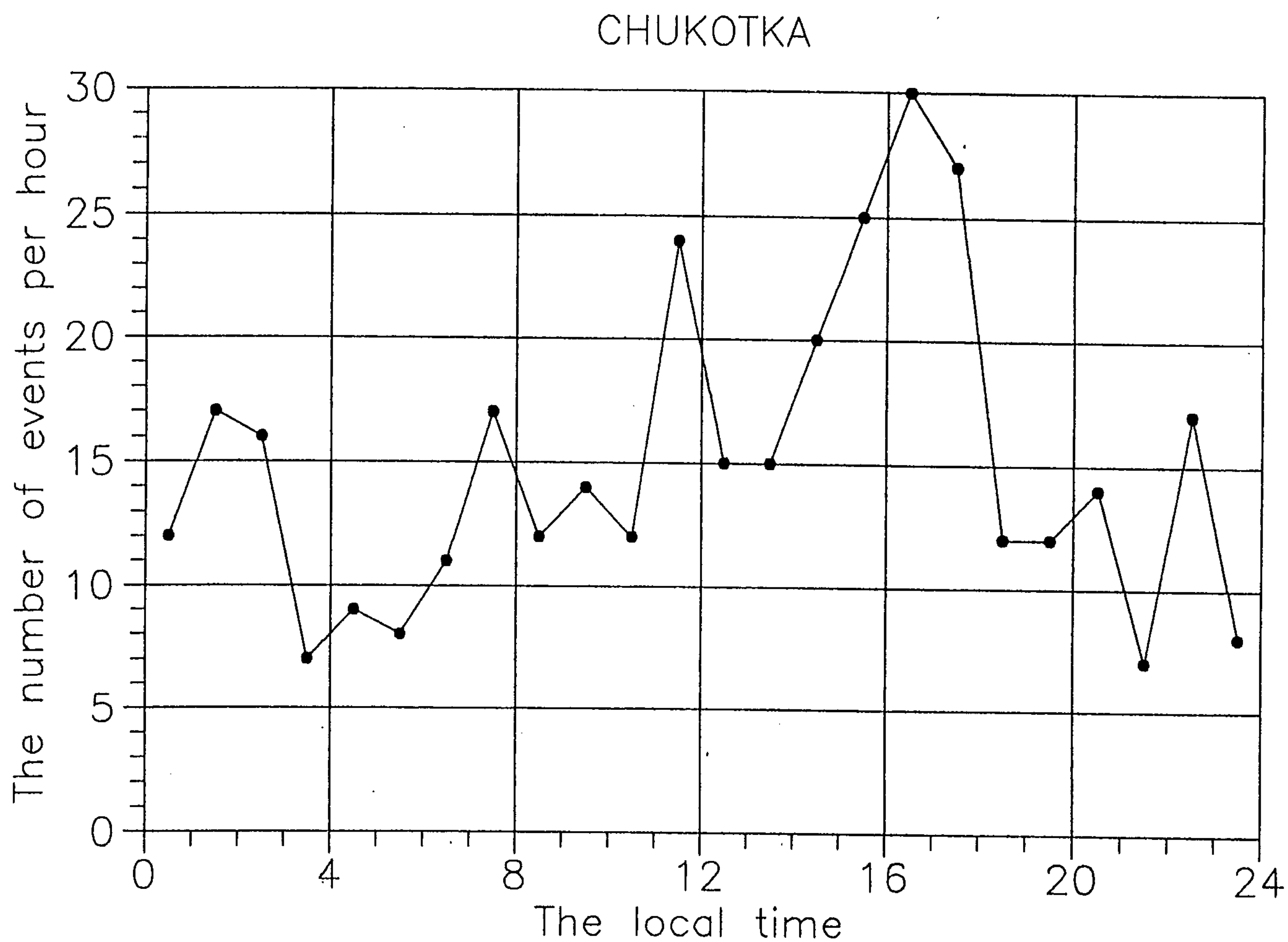

Figure 24.4. Map of epicenters of small (K ≤ 10) Chukotka events that occurred during the time of low blasting activity, before 0700 and after 1700 hours local time (see Fig. 24.2). Areas marked A, P, S, W still have some seismicity, but it would appear that area A has a significant number of blasts (see the high number of events for this region in Fig. 24.3.). Data are mostly from ESSN catalogs for 1962 – 1990.

An Analysis of Earthquake Catalogs for Territory of the Former Soviet Union: How Many Chemical Explosions Do They Contain?

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INTRODUCTION

Earthquake catalogs are produced by numerous organizations from routine analysis of seismic signals recorded at local, regional, and teleseismic distances. Such catalogs are usually intended to provide databases on natural seismicity, and they are commonly used, for example, to study the frequency distribution of earthquakes of different magnitude. However, in regions of significant blasting activity, whether from quarries or mines, from construction activities, or military programs, it is common to find that some events reported in earthquake catalogs are in fact chemical explosions.

Quarry and mine blasting is found throughout the territory of the former Soviet Union (FSU). In areas where regional seismic networks have been operated, it has been common for information on blast times to be given by the industrial organizations, responsible for blasting, to the operators of regional networks, in order that blast events can be excluded from earthquake catalogs produced by the network operators. However, such exchanges of information did not always occur effectively, and in this report we describe the outcome of a survey of published earthquake catalogs for the FSU with the goal of documenting the extent to which such catalogs appear to contain chemical explosions rather than earthquakes alone.

A substantial discussion of the problem of explosions existing in earthquake catalogs has recently been published by Godzikovskaya (1995). She pointed out that the spatial patterns of earthquakes, needed for evaluation of seismic hazard and risk, can be distorted if the patterns are inferred from catalogs that include unknown explosions.

For this report on explosions listed in what are supposed to be earthquake catalogs, our data came principally from three different catalogs. The first catalog is provided by what is known as the ESSN, which indicates the Russian title for what in English is called the Unified System of Seismological Observation. Since 1962, the ESSN has issued the annual "Earthquakes in the USSR". Each region generates seismic data separately, and is included in a separate part of this annual ESSN publication, which provides origin times, epicenters, depths, and energy class K. The lower limit on K is usually 9, though some regions give data on events with K in the range down to 8 or even 7. The second catalog we used is referred to as OBN, and is published by the Seismological Center at Obninsk (this Center was first called an Observatory, and then became the Experimental-Methodological Expedition). Obninsk collected preliminary information from basic stations of the Soviet Union on a daily basis, and determined origin times, epicenters, and depths;

and also magnitudes from the *P*-wave (MPVA and MPVB) and a surface-wave magnitude (MLH). The lower level of magnitude is about 4. Obninsk issued catalogs for each ten-day period, about two months in arrears. The third catalog we used is that provided by the International Seismological Centre (ISC) in England, which appears about two years in arrears. It is probably not complete even at the magnitude 4.5 level. However, in many areas of the world, the ISC publishes the location of events smaller than magnitude 4, using the reports of regional networks.

METHOD OF ANALYSIS

To decide the extent to which explosions are present in a claimed earthquake catalog, our principal technique was to study the distribution of events with time of day. The natural seismicity pattern is independent of time of day, and in some regions such as the Aldan [to the east of Baikal] there is no sign of time dependence (see Figure 1). We conclude for such regions, that even if quarry blasting or other chemical explosion activity occurs, it has been effectively excluded from the catalog. We also used spatial clustering of epicenters, together with time of day, to identify quarry blasting.

In practice, chemical explosions usually occur toward the end of the workday (see Figure 2) and/or at lunch time (see Figure 3). Explosions occur occasionally at night, but our general point is that different quarries develop their own programs of blasting, and their time schedules are distinctly different from the random time of occurrence of earthquakes, so that the presence of explosions makes the time distribution of seismic events "abnormal."

In some regions that we believe were reporting explosions rather than earthquakes, the distribution of events during the daytime contained a clear narrow peak around 1600 hours local time (see Figure 4). But the shape of the peak can differ (see Figure 5), depending on local practice. If the level of natural seismicity is low, then even an unusually wide peak can be identified with confidence (see Figure 6). In other cases a wide peak can be found only after detailed data analysis. We believe the events making up such peaks (narrow or wide) are mostly explosions. The average number of natural earthquakes can be found from data on the rate of event occurrence at times when probably there are no explosions. The total number of explosions can be estimated as the sum of all events that occurred during the time of abnormally many events (duration T, say), minus T times the average rate of occurrence of natural seismicity.

As a first step the number of probable explosions, included in catalogs as earthquakes, was estimated from total data of several different regions. Then the more probable quarries were chosen on the map of the epicenters as a spot of high density of epicenters which occurred close to the local time about 1600 hours. Analyzing all data from these small areas the probable number of explosions can be estimated as a second step, more accurate than the first.

More specifically, the steps are as follows. First, the time distribution of all data in the catalog shows if there is a peak, created probably by explosions. Then the map of epicenters has to be plotted, using the events that occurred in the time interval corresponding to the peak of the distribution. On such a map the clusters of epicenters are visible more clearly. They can be

assumed to be quarry blasts (or aftershocks). Second, an iteration of time distribution for these particular areas is needed. The analysis of data on magnitudes prevents the exclusion of earthquake aftershock clusters. The time distribution of events from these areas of clustered events makes clear the presence of explosions. It then becomes possible to estimate the number of explosions, their percentage in this area, and sometimes even to give a list of the explosions.

In the following section, we describe five regions for which we carried out one or more studies; and we indicate the different catalogs used in each case.

EXAMPLES

1) First we shall look at the Carpathian region (45–50 °N, 20–30°E), for years 1962–1990, using ESSN and ISC. This region gives a clear peak with a width of six hours (1300 to 1800 hours, local time), as shown in Figure 7. The average level of natural seismicity (outside this six hour interval) is 54 per hour. The total number of events during the six hours is 530. Excluding the natural seismicity (54 * 6 = 324), one gets a rough estimate of the number of explosions as 530 – 324 = 179. This is a high percentage: about 34% of the events recorded in the catalog during work hours, and supposed to be earthquakes, appear to be quarry or mining blasts.

Table 1. The distribution of events in seven small areas A - G of the Carpathian Region (see Figure 8), that we believe are quarries

GMT	A	B	C	D	E	F	G	SUM
0.5								0
1.5							1	1
2.5								0
3.5								0
4.5								0
5.5								0
6.5				2		1	2	5
7.5			1		4	1		6
8.5					2		2	4
9.5					4	2	1	7
10.5	1		2	2	4	4	1	14
11.5	8	6	8	3	2	7	2	36
12.5	13	4	2		2	3		24
13.5	1	7	1		1	4	2	16
14.5		1			5	13	2	21
15.5	1	1			6	14		22
16.5					1	4		5
17.5		1				1	1	3
18.5					1			1
18.5					1			1
20.5						2		2
21.5					1			1
22.5					1	1		2
23.5							3	3

Seven small areas, labelled A – G within this region, were identified as localized quarry blasts. They are shown on the maps given as Figure 8 (epicenters of events within 1300 to 1900 hours) and Figure 9 (events outside this six-hour time interval). One can see how the epicenter pattern differs in these two time intervals.

As an additional step, the time distribution of events within each area was studied (see Table 1). The areas A, B, C, D appear to contain explosions only. Areas E, F, and G probably include a few earthquakes. The time interval of blast activity is somewhat different from different regions — and this appears to be why the time distribution for the total region is quite wide, say from 0900 to 2000 hours.

The total number of events (see Figure 10) in areas A – G, which we suppose to be quarries or mines, is 184. The number of events that occur within 0900 to 200 hours is 166. This number is quite close to our first estimate for the Carpathians during the time period 1962–1990.

2) Another example for the European part of the former Soviet Union is the region around the Gulf of Finland (56–62°N, 22–30°E). The data were obtained from the ISC catalog, for the years 1964–1987. The time distribution of events here shows a difference from year to year (see Figure 11). The time distribution differs for active years (1967–1973) and for quiet ones (see Figure 12). Figure 13 shows the epicenters of events, using different symbols for events that occur during the active years in the day-time, and for events that occur during quiet times. Note that some of the epicenters shown in this Figure indicate multiple events with identical coordinates.

Table 2. The list of events, which are probably explosions in the Gulf of Finland, 57-62° N, 22-30° E: ISC data, 1964-1987.

Year	Mo	Da	Ho	Mi	Sec	Latit	Longit	mb
Sortavala								
1964	10	22	10	25	21.0	61.75	28.75	
1966	9	7	10	3	33.0	61.30	27.80	
1967	10	25	11	54	32.0	61.40	29.80	
1968	9	21	11	30	12.0	61.90	29.70	
1969	10	14	11	52	0.0	61.70	29.30	
Narva								
1967	2	13	15	48	24.0	59.30	26.40	
1967	2	15	14	6	55.0	59.20	26.10	
1967	2	17	13	15	58.0	59.20	26.10	
1971	4	8	13	21	4.0	59.30	28.20	
1973	1	13	12	31	30.0	59.40	28.30	
1973	1	19	12	37	19.0	59.30	28.10	
1973	5	7	12	14	40.0	59.50	27.80	
1973	5	10	13	31	55.0	59.50	28.50	
1973	5	10	14	45	30.0	59.50	28.50	
1973	5	15	12	28	16.0	59.40	28.30	
1973	5	19	12	10	45.0	59.40	27.40	

(Table 2, continued)

1973	5	23	13	17	22.0	59.20	28.30	
1973	5	24	12	46	51.0	59.30	28.00	
1973	5	28	14	13	15.0	59.20	27.50	
1973	5	28	14	13	23.0	59.20	27.50	
1973	5	29	13	7	35.0	59.60	27.70	
1984	3	23	12	12	38.0	59.50	27.60	3.3
Tallinn								
1964	5	6	11	21	0.0	59.60	24.70	
1964	9	5	13	20	27.0	59.50	25.00	
1965	3	22	11	35	33.0	59.90	22.70	
1965	7	2	18	58	57.0	59.60	24.40	
1966	10	30	12	1	37.0	57.50	23.40	
1966	12	23	8	20	19.0	59.60	24.20	
1967	5	6	14	15	27.0	59.90	24.30	
1967	5	7	11	34	14.0	59.90	24.30	
1967	5	15	13	55	15.0	59.80	24.30	
1967	6	14	13	23	7.0	59.80	24.30	
1967	6	23	11	50	32.0	59.50	25.60	
1967	7	27	11	39	24.0	57.30	24.40	
1967	9	21	14	54	46.0	59.80	23.40	
1968	4	17	12	15	4.0	59.90	23.50	
1968	9	26	15	12	48.0	59.40	22.70	
1969	4	3	14	27	20.0	59.70	25.60	
1969	4	11	12	40	31.0	59.70	25.60	
1969	4	15	12	42	57.0	59.70	25.60	
1969	4	22	12	53	35.0	59.70	25.60	
1969	4	23	13	3	42.0	59.70	25.60	
1969	4	29	12	31	11.0	59.70	25.60	
1969	5	8	10	54	44.0	59.70	25.60	
1969	5	16	11	7	27.0	59.70	25.60	
1969	5	23	13	34	11.0	59.70	25.60	
1969	5	28	13	25	40.0	59.70	25.60	
1969	6	6	13	2	28.0	59.70	25.60	
1969	6	11	12	2	36.0	59.70	25.60	
1969	6	16	11	58	24.0	59.70	25.60	
1969	6	20	12	13	5.0	59.70	25.60	
1969	6	26	13	19	18.0	59.70	25.60	
1969	7	16	13	38	15.0	59.70	25.60	
1969	7	18	11	29	51.0	59.70	25.60	
1969	7	30	11	26	25.0	59.70	25.60	
1969	8	18	12	26	12.0	59.70	25.60	
1969	8	19	12	1	32.0	59.70	25.60	
1969	8	20	11	20	36.0	59.70	25.60	
1969	12	9	8	34	50.0	59.70	25.60	
1969	12	25	12	7	56.0	59.70	25.60	
1970	1	14	12	33	50.0	59.70	25.60	
1970	4	1	10	12	5.0	59.70	25.60	
1970	4	6	13	33	41.0	59.70	25.60	
1970	4	15	17	18	25.0	59.70	25.60	
1970	4	21	12	59	3.0	59.30	24.20	
1970	5	18	12	35	12.0	59.70	25.60	
1970	5	23	12	30	35.0	59.70	25.60	

(Table 2, continued)

1970	6	8	13	51	46.0	59.70	25.60
1970	6	15	15	3	53.0	59.70	25.60
1970	6	18	11	15	31.0	59.70	25.60
1970	6	24	12	57	15.0	59.70	25.60
1970	6	24	13	9	13.0	59.70	25.60
1970	6	29	16	10	2.0	58.70	22.70
1970	7	1	12	10	25.0	59.70	25.60
1970	7	6	12	51	10.0	59.70	25.60
1970	7	7	12	55	26.0	59.70	25.60
1970	7	17	12	11	9.0	59.70	25.60
1970	7	20	12	9	44.0	59.70	25.60
1970	7	30	13	0	36.0	59.30	24.10
1970	7	30	18	1	18.0	59.43	22.40
1970	8	1	10	47	23.0	59.70	25.60
1970	8	4	13	32	33.0	59.70	25.60
1970	8	10	16	54	5.0	59.30	24.10
1970	8	11	12	8	35.0	59.70	25.60
1970	8	13	12	1	32.0	59.70	25.60
1970	8	20	12	39	6.0	59.70	25.60
1970	8	25	12	18	43.0	59.70	25.60
1970	9	15	12	48	3.0	59.70	25.60
1970	9	18	13	24	25.0	59.30	24.10
1970	10	5	14	20	37.0	59.70	25.60
1970	10	9	12	9	41.0	59.70	25.60
1970	10	12	12	59	39.0	59.70	25.60
1970	10	13	12	57	46.0	59.30	23.40
1970	10	13	13	0	15.0	59.30	23.40
1970	11	20	11	54	0.0	59.30	24.10
1971	1	12	12	59	58.0	59.40	23.60
1971	1	15	12	50	0.0	59.50	25.10
1971	1	26	13	46	23.0	59.50	25.10
1971	3	31	12	40	49.0	59.50	25.10
1971	4	6	13	0	31.0	59.20	24.20
1971	4	9	11	52	11.0	59.50	24.90
1971	5	4	13	26	58.0	59.50	24.80
1971	5	13	14	2	29.0	59.70	25.60
1971	5	27	12	28	36.0	59.50	25.00
1973	1	23	12	5	0.0	59.40	25.30
1973	5	8	12	17	12.0	59.50	24.90
1973	5	14	12	1	54.0	59.60	24.70
1973	5	15	12	59	0.0	59.20	24.20
1973	5	16	14	18	34.0	59.60	24.30
1973	5	17	14	35	54.0	59.70	24.20
1973	5	18	12	15	23.0	59.40	23.40
1973	5	21	12	13	34.0	59.50	24.80
1973	5	22	13	22	30.0	59.30	25.00
1973	5	23	17	44	37.0	59.60	22.20
1973	5	23	18	0	44.0	59.60	22.20
1973	5	23	18	17	44.0	59.60	22.00
1973	5	23	18	18	0.0	59.60	22.00
1973	5	25	11	9	30.0	59.50	25.20

(Table 2, continued)

1973	5	26	8	38	52.0	59.60	24.00	
1973	5	26	8	41	31.0	59.60	24.00	
1973	5	26	8	41	49.0	59.60	24.00	
1973	5	29	13	0	50.0	59.50	23.30	
1973	5	30	10	31	26.0	59.30	25.50	
1973	11	3	12	6	51.0	59.80	22.20	
1974	4	19	15	29	3.0	59.70	23.90	
1974	6	22	13	30	19.0	56.75	25.50	
1975	11	14	12	51	43.0	59.50	25.00	
1976	10	25	8	39	44.7	59.20	23.58	4.4
1976	11	8	10	17	5.0	59.60	23.20	
1978	3	26	15	48	42.3	59.43	23.64	
1981	6	22	18	53	19.6	59.73	22.42	
1982	7	10	8	28	39.0	59.40	23.70	

Three places on the Figure 13 map are indicated as separate blasting locations. They are to the west, in Estonia; to the east, near the town of Narva at the boundary of Estonia and Russia; and in the south-east of Finland near the boundary of Finland and Russia, close to the Russian town of Sortovala.

Table 2 gives the list of events which are probably explosions near the Gulf of Finland. The total number of events within the 17 quiet years is 39, that is, about 2 a year. So about 15 events during seven active years are expected to be earthquakes. The number of events during these seven years is 124, of which 100 occurred during the daytime. Only a very few of the events in Table 2 can be earthquakes.

3) Eastern Siberia (60–72°N, 115–165°E) is a region with high natural seismic activity. Within the years 1962–1990 of our analysis, 3296 earthquakes were documented. 3245 of them are the the ESSN catalog. OBN and ISC listed only the larger events (74 have m_b in the range 3 to 5.9, and 23 have M_s in the range 4.1 to 7.1). 3238 events have the energy class K determined. (It is known that quarry blasts usually have small seismic signals. In the FSU, their K value is usually less than 9 (magnitude less than 3.25)).

The ESSN data for Eastern Siberia for the years 1960–1990 (Figure 14) show a significant peak near 1600 hours local time for small events, and no peak for 614 larger ones.

In the wide territory of Eastern Siberia the total number of small events (K ≤ 9) during 2 hours between 1400 and 1600 hours is 310. During the other 22 hours the number per hour is 105. Consequently the total number of events which are probably quarry blasts is estimated as $310 - 210 = 100$. If we take the explosion-time interval to be as long as 9 hours, from 1100 to 2000 hours local time, the total number of events included is 1120, whereas during the other 14 hours the number per hour is about 100. In this case the estimate of the total number of explosions is $1120 - 9*100 = 220$.

The map of epicenters (see Figure 15) is plotted only for small events ($K \leq 9$) and for a six hour period (1300 to 1900 hours local time). There are many clusters of epicenters. Part of them were created by aftershocks following large earthquakes. Other ones (marked by squares) do not include large earthquakes and their time distribution is "abnormal" for earthquakes. We therefore believe they were explosions. The distribution in time for the events within areas A – G is shown in Figure 16.

The average rate of occurrence of seismic events at quiet times (2300 hours to 1300 hours) is about 4 per hour. The total number of events within the interval from 1400 to 2100 hours is 120. Excluding the expected number of earthquakes during these seven hours, one gets the number of explosions as $120 - 4*7 = 92$.

4) The Chukotka region (60–72°N, 165–190°E) is the part of Russia that is closest to Alaska. Our list of events or this region was obtained mostly from the ESSN (427 events), with some from OBN (39) and some from ISC (29). We studied data for the years 1970–1990. About 300 events are quite small ($K < 9.1$) and these were used to find a blasting area. The time distribution (see Figure 17) for these 300 events shows a peak between 1100 and 1700 hours local time. The total number of events during these six hours is 116. The average level of the natural seismicity in quiet times is 10 per hour. So the number of explosions was calculated as $116 - 10*6 = 56$.

The maps shown as Figures 18 and 19 indicate the events that occurred during the interval of active blasting (solid circles) and out of this interval (open circles). It is seen that there is a spot of high epicenter density at the northern part of the region. It is close to the dam of the Amguemskays Hydro Power Station. The time distribution of events, localized within the rectangular zone (see Fig. 18) indicates that most of these events are explosions. The seismologist Yugova, working at the Yultin station 20 km from the dam, has collected data on explosions in the region. According to her information, there were several hundred explosions during 1981–1984, of which 15 were included in the ESSN catalog. Our estimate for the time up to 1990 gives a number about 54 from the first procedure (see above) and 40 for the zone near the dam.

5) The territory of the Southern Urals and North-Western Kazakhstan, surrounding the Tengiz Oil Fields were studied to estimate the number of chemical explosions reported as earthquakes. From the catalogs available we found 23 seismic events (see Table 3):

These are not small events and are not included in official lists of underground nuclear explosions. The existence of three historical events in the 19-th century (prior to the development of modern-day blasting practices) indicates that these events can be earthquakes. But all these events occurred during the day, from 0700 hours to 20 hours local time. The couple of tens of events in the Table does not provide rich statistics, but they are enough to be sure that such an inhomogeneous distribution is not random. Most of the events listed in Table 3 are chemical industrial explosions.

Table 3. Seismic events with epicenters around Tengiz.

Year	Mo	Da	Ho	Mi	Sec	Latit	Longi	Mb	MPVA	MLH	K	Source	
1839						52.00	48.00					SeiReg*	
1885						51.90	48.10					SeiReg	
1885						52.00	55.00					SeiReg	
1968	6	14	6	1	31.0	45.00	55.30	4.3				ISC	QB?
1970	8	9	2	24	2.0	48.60	55.60	4.0				ISC	
1971	12	6	12	51	46.7	45.00	54.80					ISC	
1974	10	13	9	56	7.7	48.41	53.59	4.1				ISC,ESSN	
1976	2	6	14	50	18.5	47.32	53.28					ISC,ESSN	
1976	4	20	9	2	28.9	46.13	59.82					ISC	
1977	11	5	13	40	40.9	46.11	51.64					ISC	
1979	2	9	11	20	40.2	44.61	45.47					OBN	
1984	4	28	14	54	1.7	49.78	46.77		4.3			OBN	QB?
1985	4	19	13	53	58.3	44.49	57.83	4.7				ISC,ESSN	QB?
1986	8	9	3	40	47.0	52.80	51.15					ESSN	
1986	11	21	11	54	58.0	51.90	47.00	3.9				NAO	
1986	12	2	9	30	29.0	50.60	46.20	3.6				NAO	
1987	8	3	6	45	11.1	48.48	46.63				8.5	ESSN	
1988	7	1	7	43	33.0	50.90	45.30	3.4				NAO	
1989	3	19	8	27	22.0	52.80	49.30	3.4				NAO	
1989	3	28	15	23	35.0	50.50	51.70	3.4				NAO	
1989	5	30	14	18	52.0	50.70	46.40	3.7				NAO	
1989	9	29	13	24	57.0	50.70	46.00	3.6				NAO	
1994	8	1	4	15	44.5	48.15	67.35		4.8	4.6		OBN	

*SeiReg refers to the monograph "Seismological Regionalization" describing regional seismicity and methods, that also has some information about events that occurred prior to the instrumental era.

SUMMARY

We conclude that in several areas of the former Soviet Union, catalogs supposedly of earthquakes only, in practice can contain numerous chemical explosions. In some of the regions we studied in detail, the numbers of explosions that have been falsely cataloged as earthquakes is so large, that there may be errors in statistical studies of earthquake distribution.

REFERENCE

Godzikovskaya, Anna A. (1995) Local earthquakes and blasts. Book, in Russian, Moscow: 98pp.

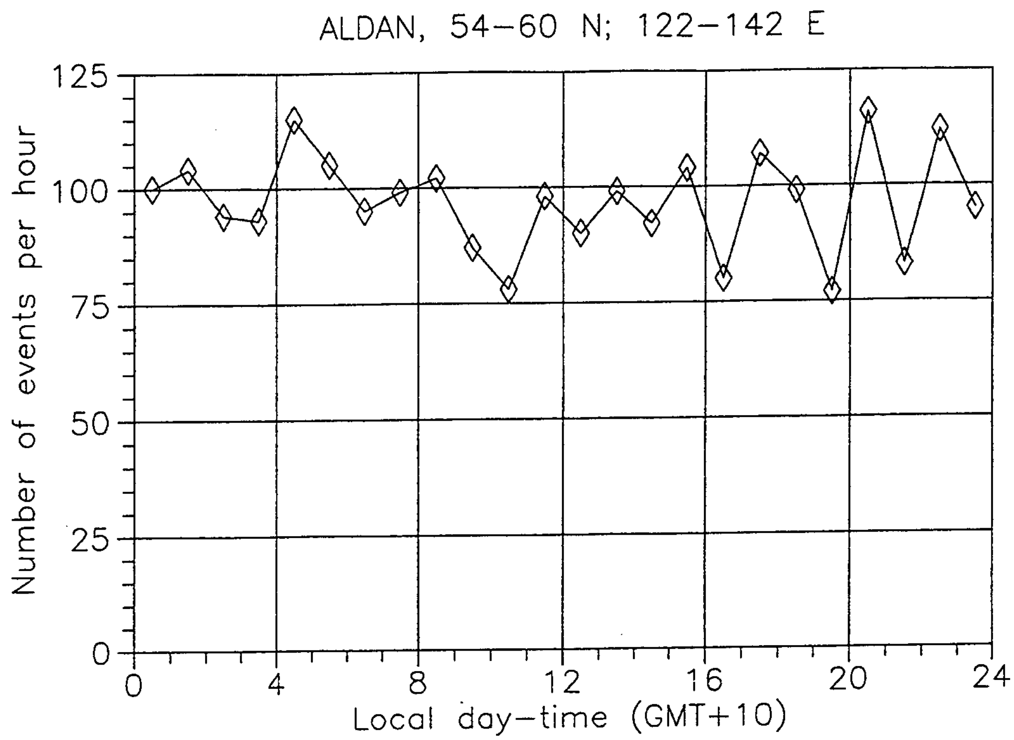

Figure 1. Distribution of seismic events vs. local time-of-day (GMT + 10) in the Aldan region during the years 1962 – 1990. This is an example of a catalog that is free from temporal clustering.

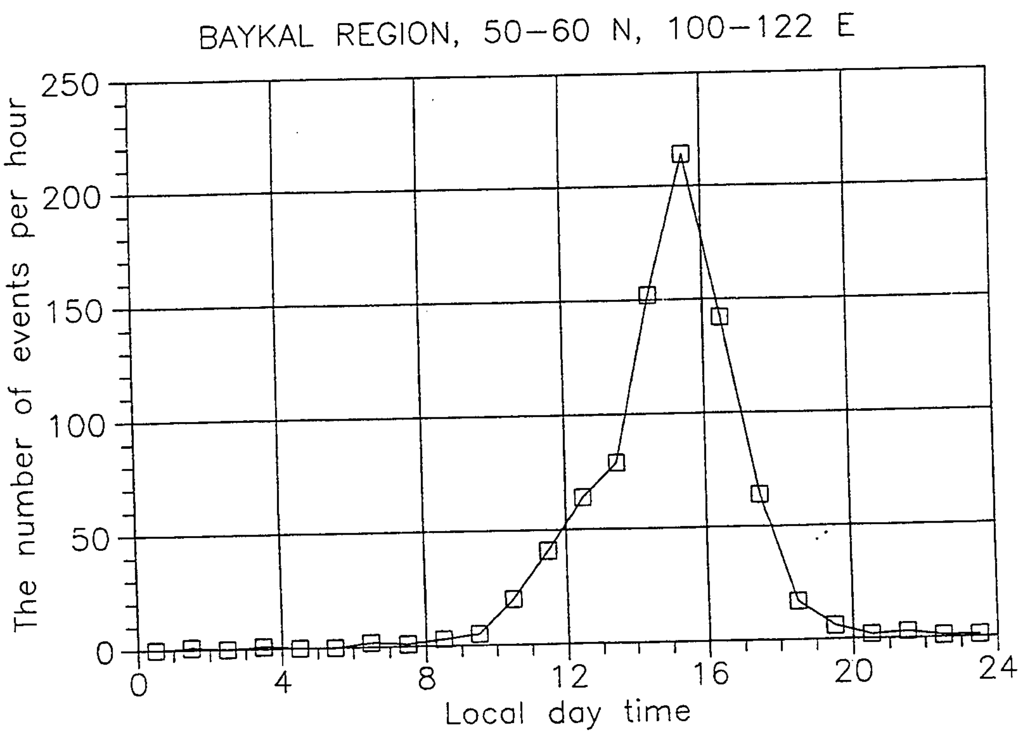

Figure 2. Distribution of seismically-detected blasting vs. local time-of-day (GMT + 8) in the Baikal region. Data are from a blast bulletin prepared by L. Delitsin for the periods Jul – Oct 1991 and Jun – Oct 1992 (personal communication).

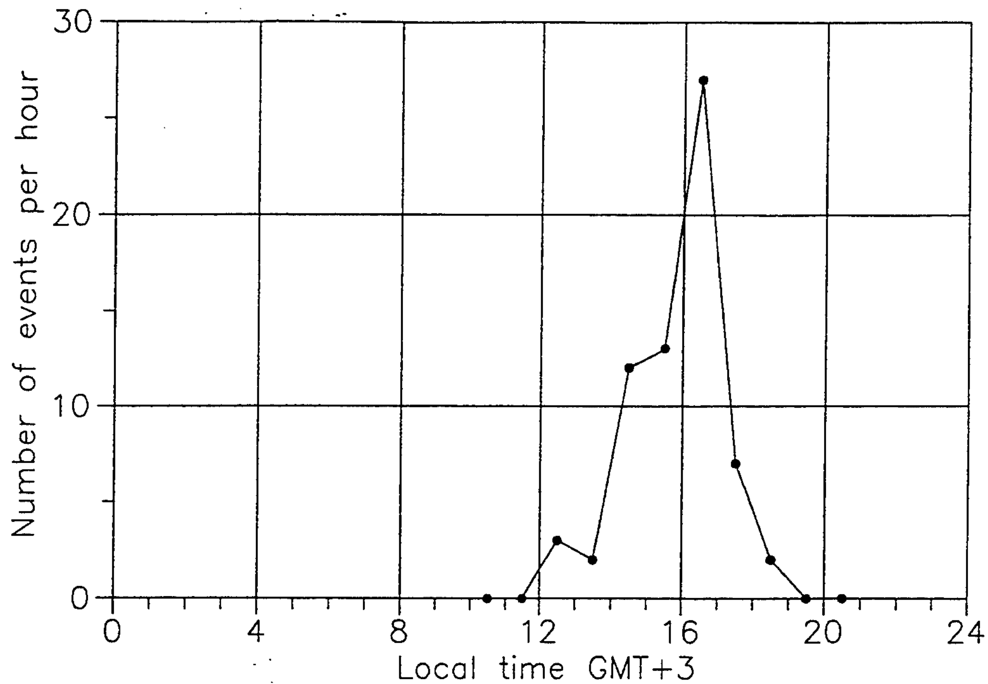

Figure 3. Distribution of seismic events vs. local time-of-day (GMT + 3) in the region near the Amguemskaya dam, Georgia, during the year 1983. Data from A. Godzikovskaya. No natural earthquakes are in this set of seismic events.

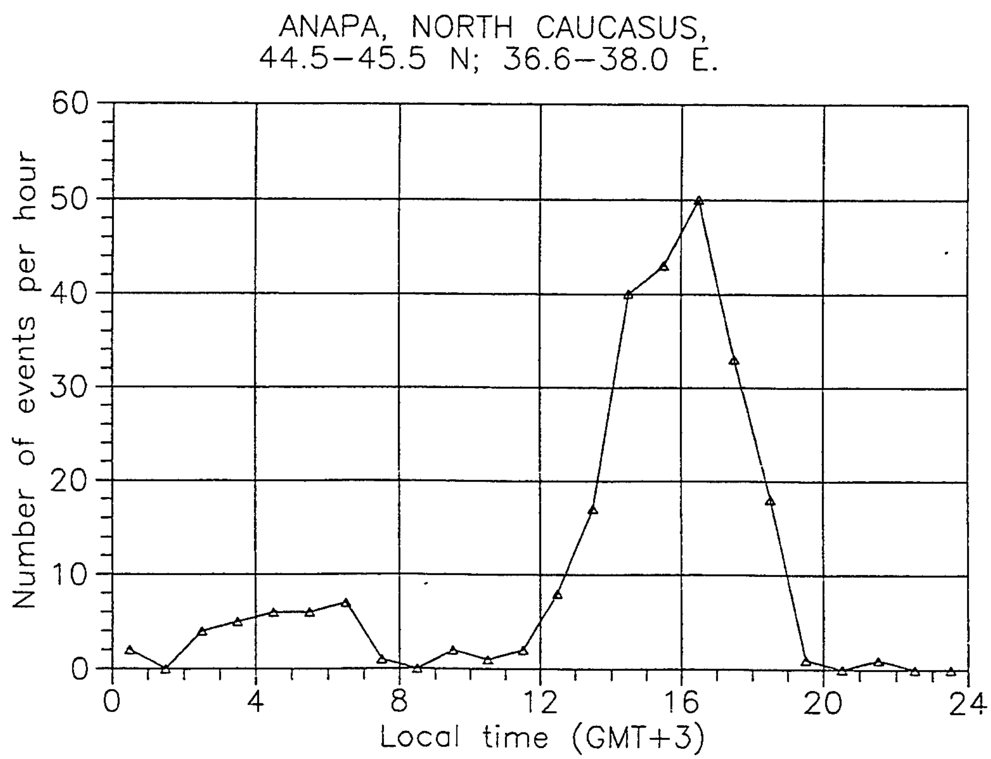

Figure 4. Distribution of seismic events vs. local time-of-day (GMT + 3) in the vicinity of Anapa, North Caucasus, during the years 1968 – 1990. Data from A. Godzikovskaya. There are two peaks: a small one in the early morning, and a large one at the end of the workday.

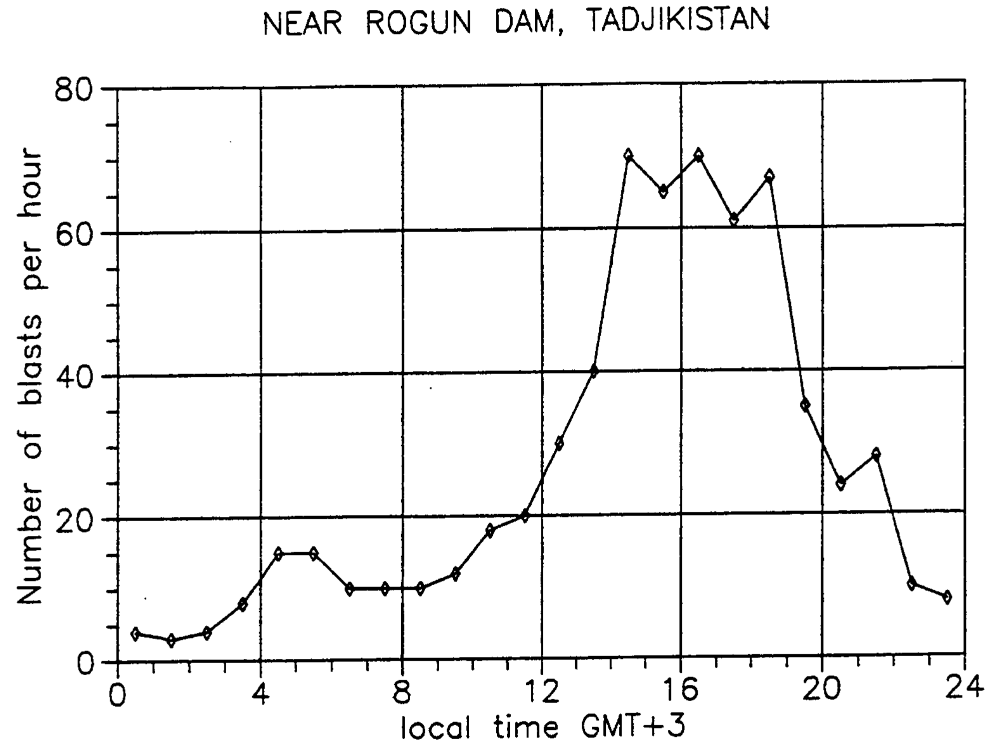

Figure 5. The distribution of seismic events vs. local time-of-day (GMT + 3) in Tadjikistan, for the region within 50 km of the Rogun dam (38.7°N, 70.15°E) during a period of special observation, Feb 1989 – Aug 1991. Data from A. Godzikovskaya.

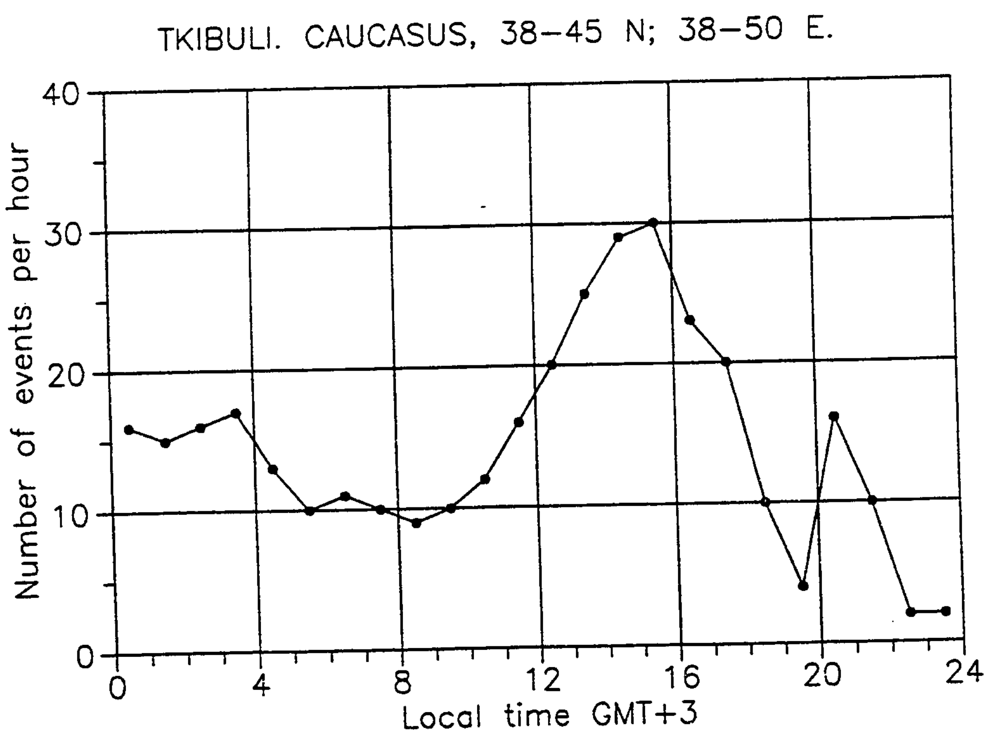

Figure 6. Distribution of seismic events vs. local time-of-day (GMT + 3) in Tkibuly, Caucasus (data from the Byely Ugol station, 1974 – 1991). Data from A. Godzikovskaya.

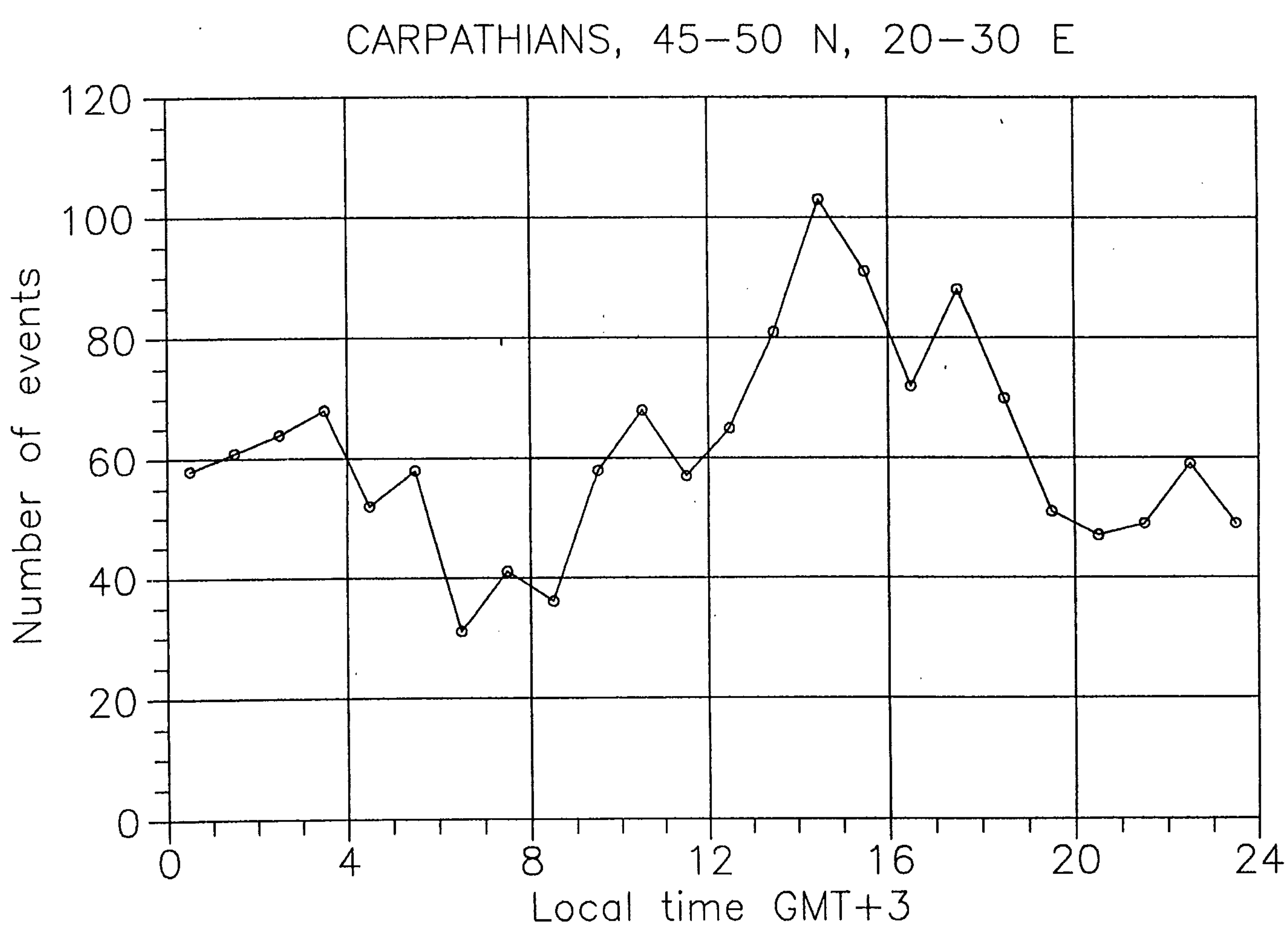

Figure 7. Distribution of seismic events vs. local time-of-day (GMT + 3) in the Carpathians. Data from ESSN and ISC catalogs, 1962 – 1990.

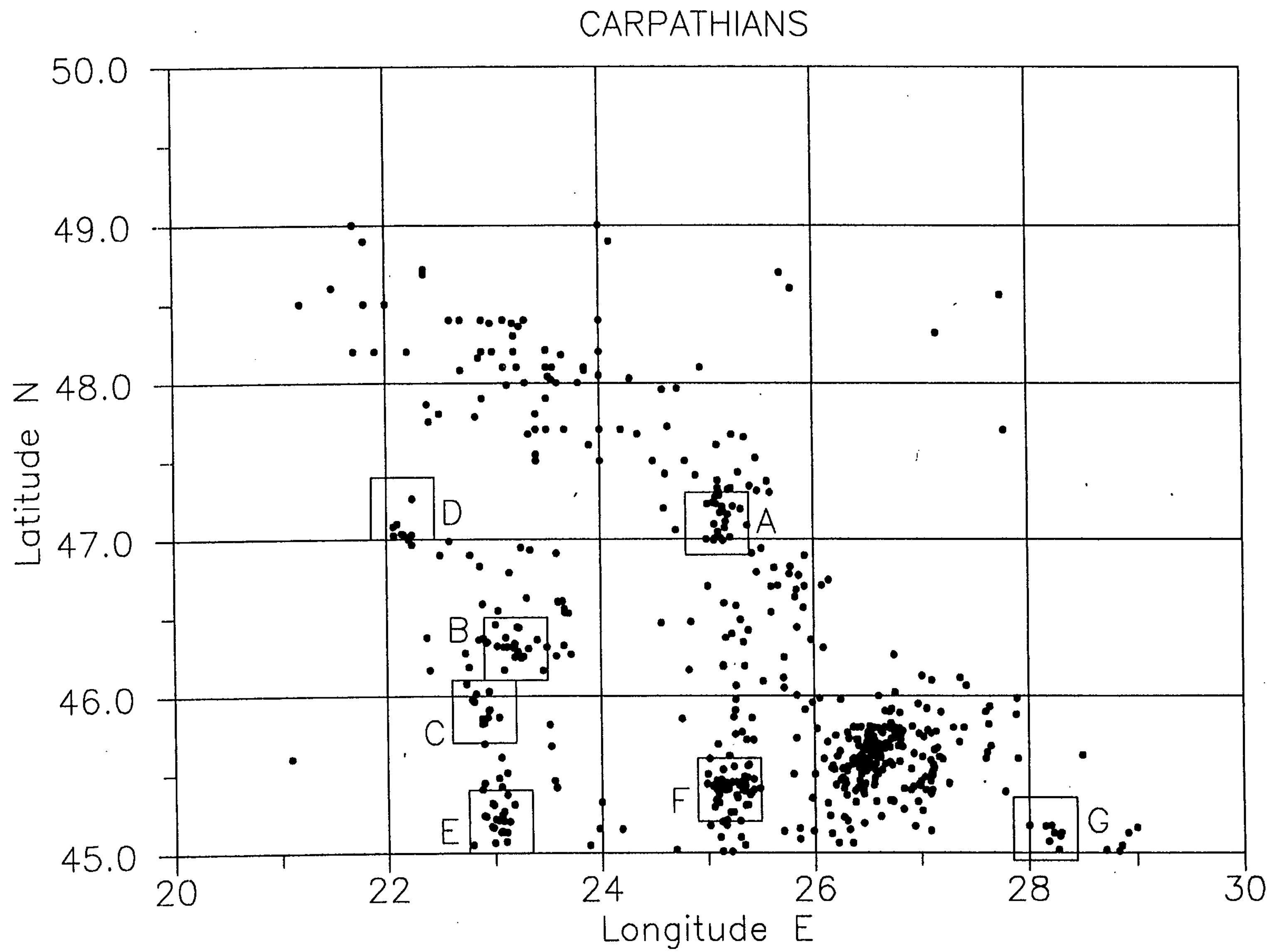

Figure 8. Epicenter map of seismic events during 1964 – 1987 that occurred during the local time period 1000 – 1500 hours. Squares labeled A – G indicate presumed mines.

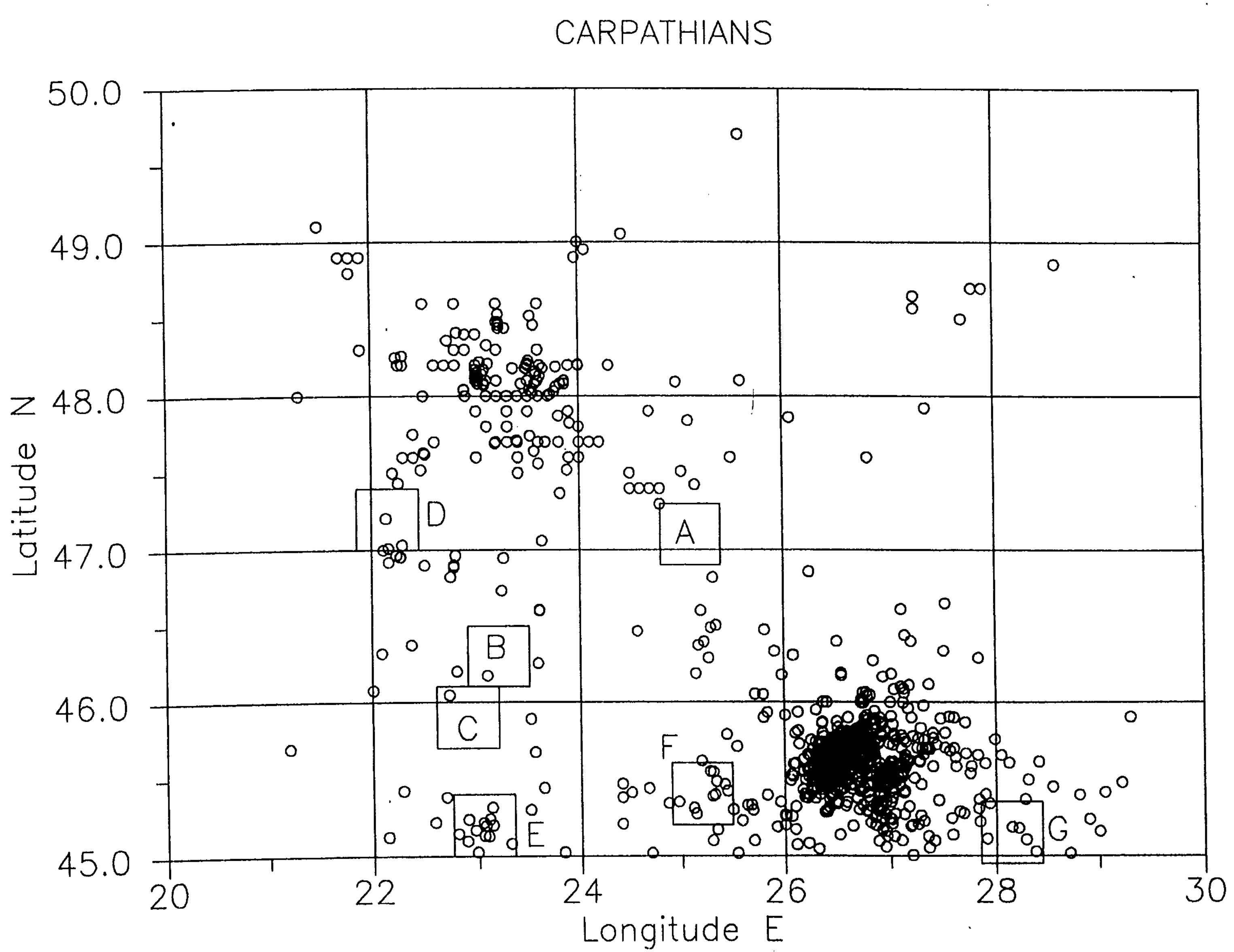

Figure 9. Epicenter map of seismic events during 1964 – 1987 that occurred during a time period when quarries and mines are not expected to be blasting. Squares labeled A – G indicate presumed mines.

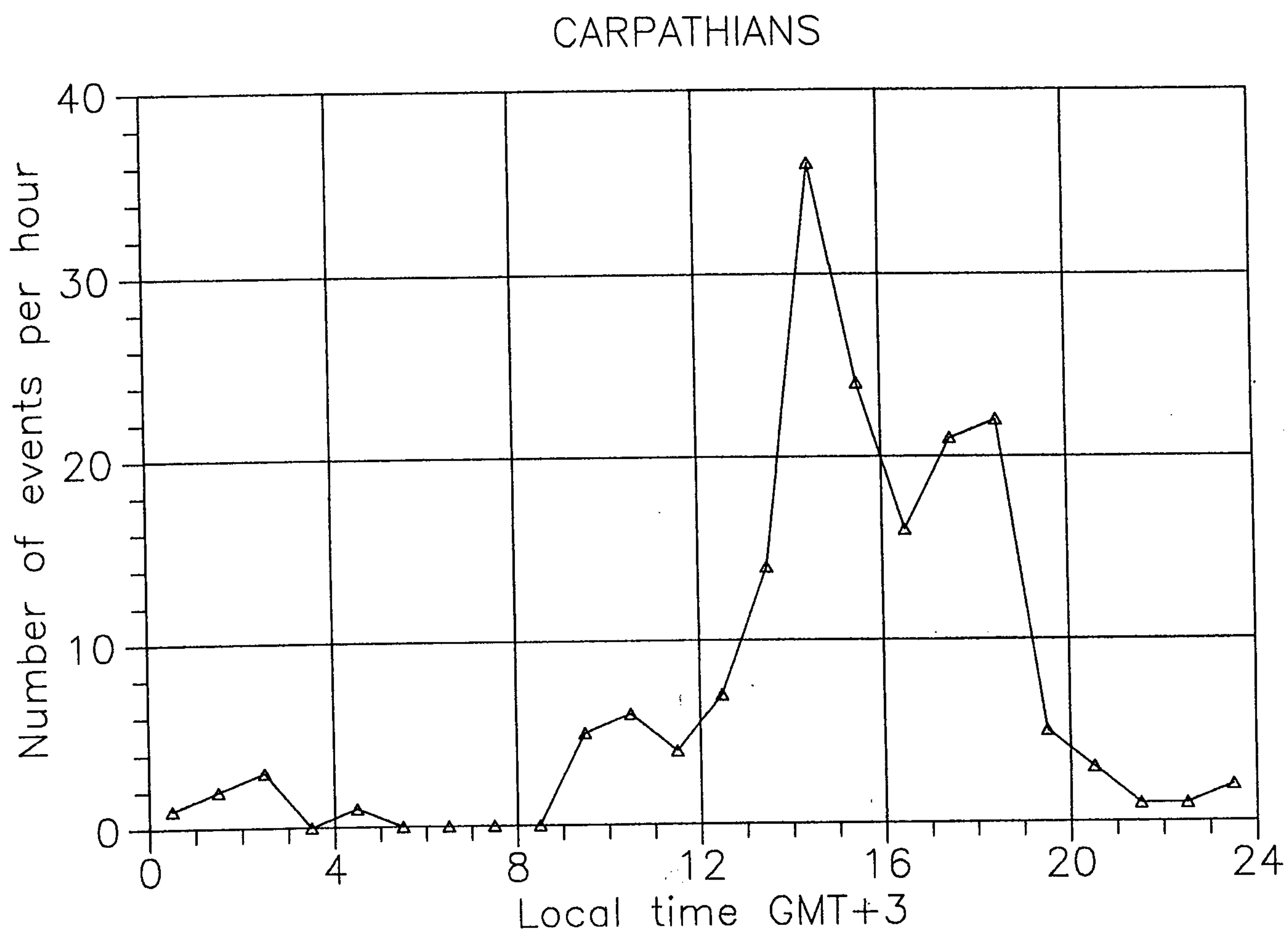

Figure 10. The number of events per hour in areas labeled A – G, which we presume are mines or quarries.

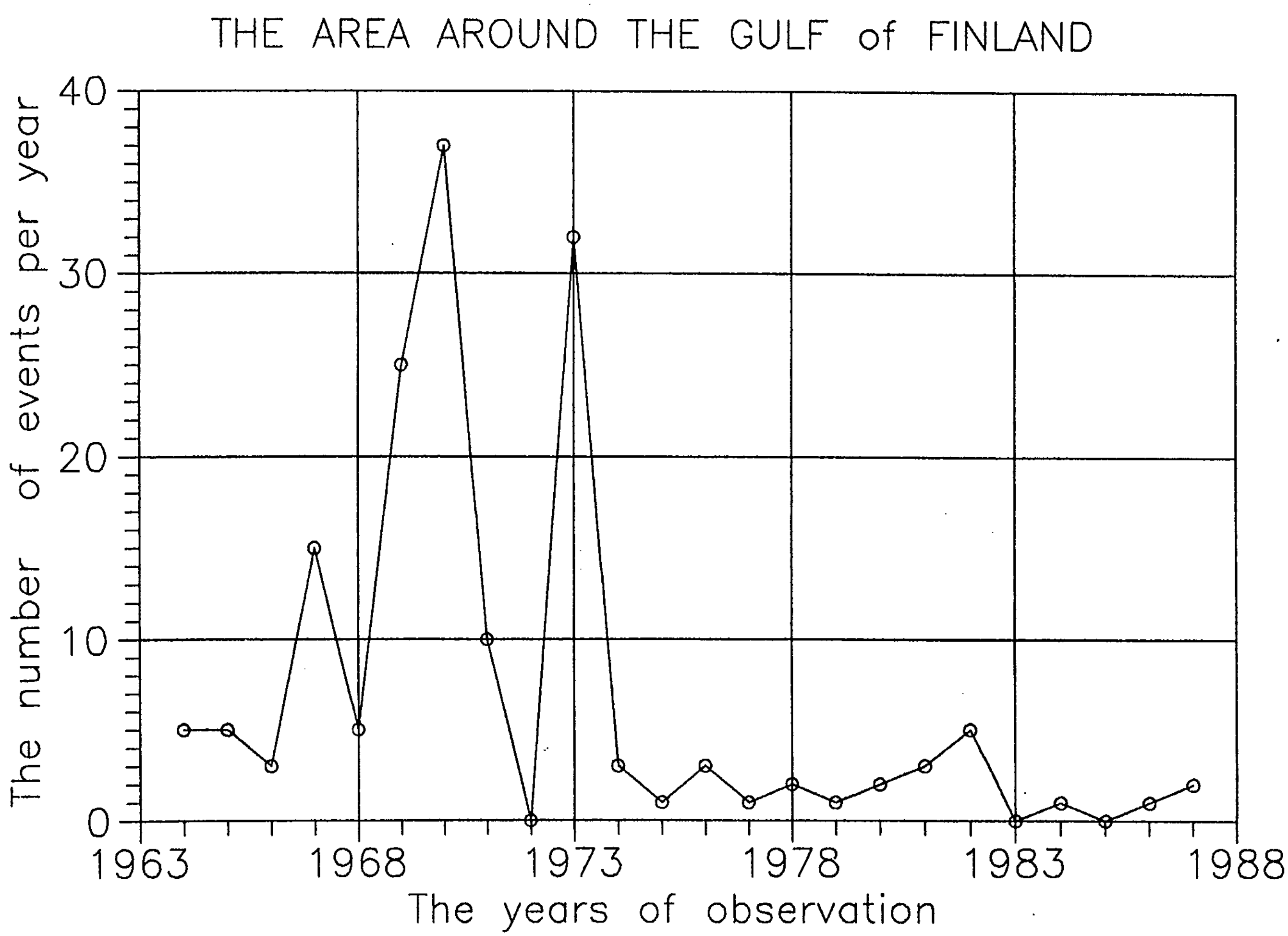

Figure 11. The number of seismic events per year around the Gulf of Finland (55–62°N, 22–30°E), for different years. Based on ISC data, 1964 – 1987.

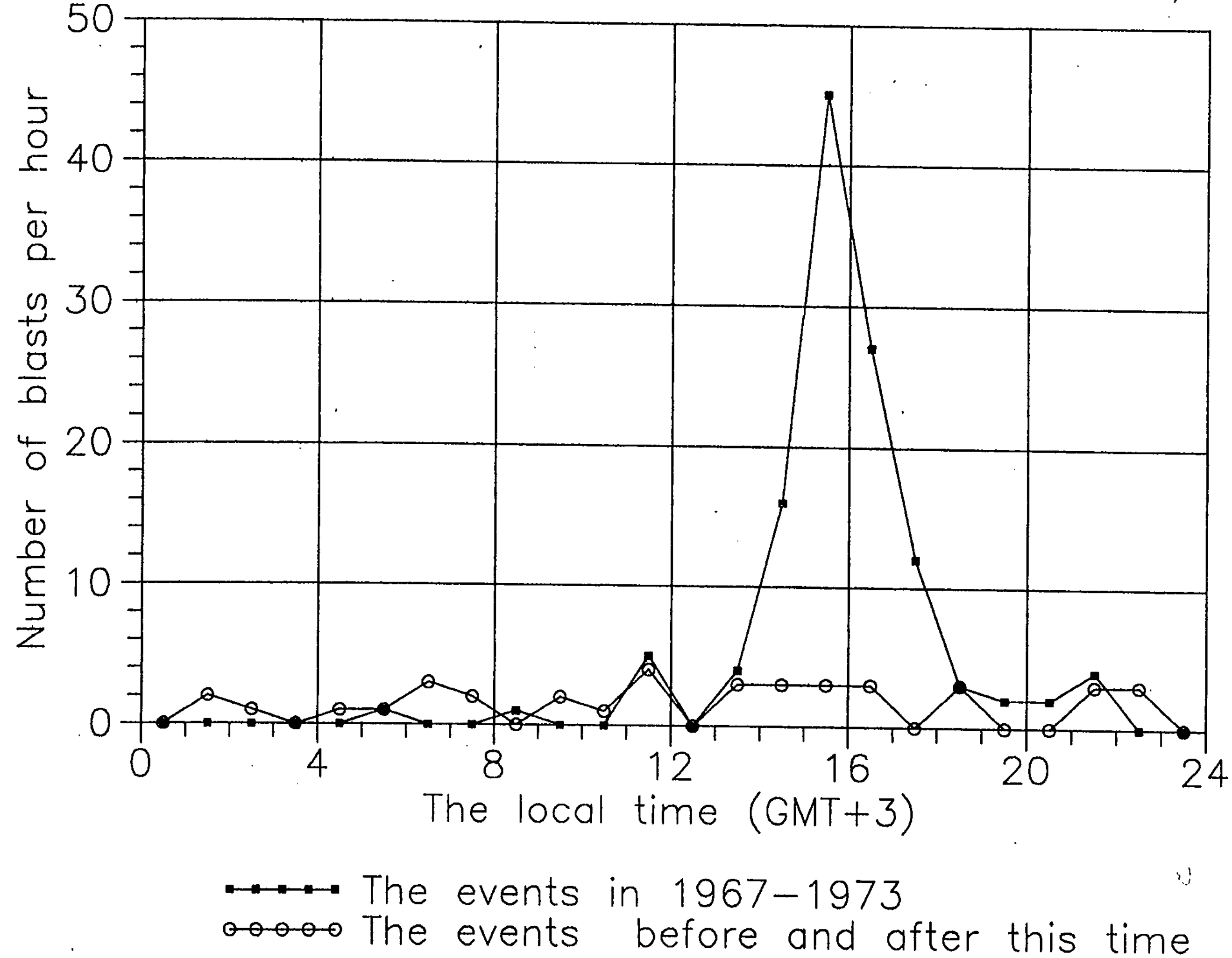

Figure 12. The distribution of seismic events vs. local time-of-day (GMT + 3) around the Gulf of Finland, done separately for years of high activity (1967 – 1973) and for years of low activity (1964 – 1966 and 1974 – 1987). ISC data.

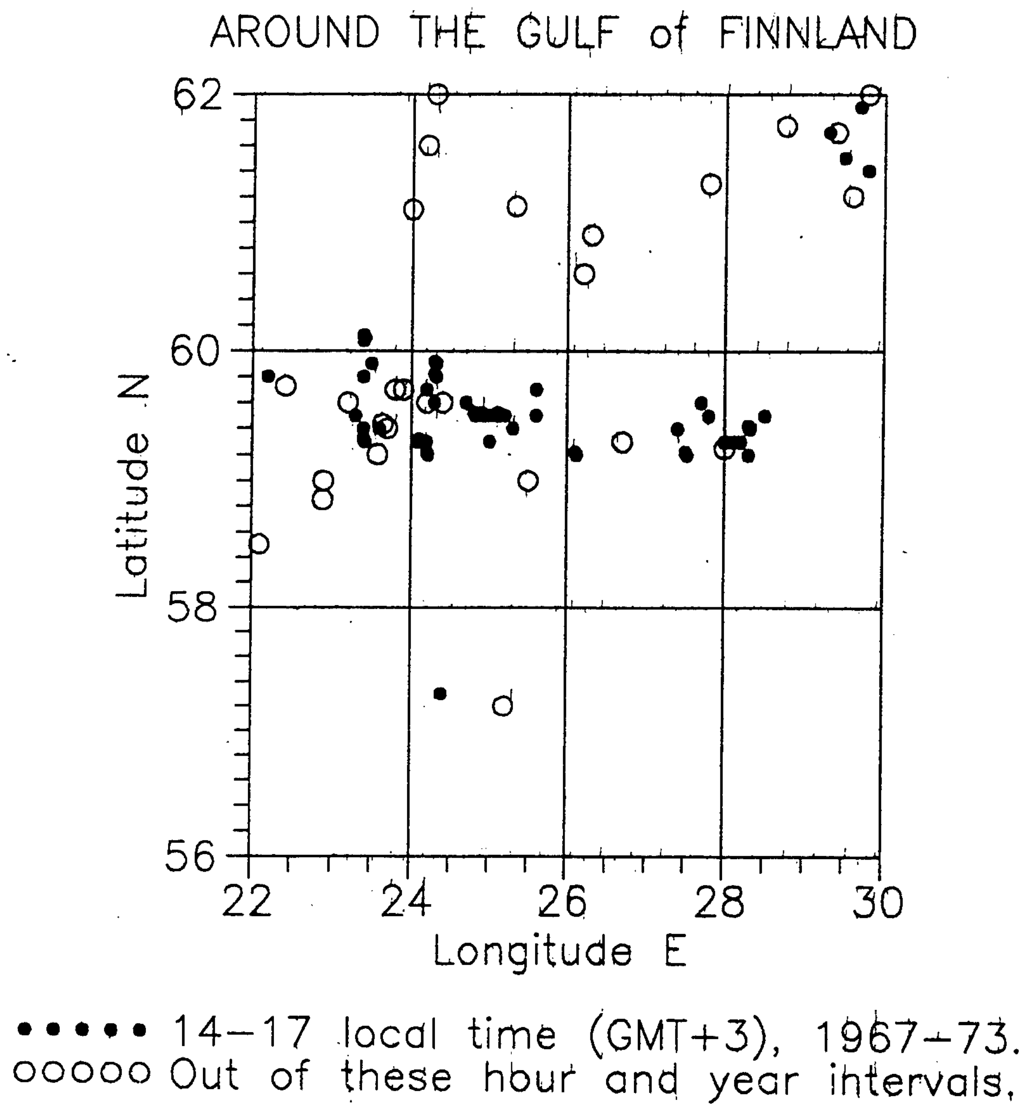

Figure 13. Map of epicenters in the area around the Gulf of Finland. ISC data, 1964 – 1987. There are 45 events at (59.6°N, 25.6°E).

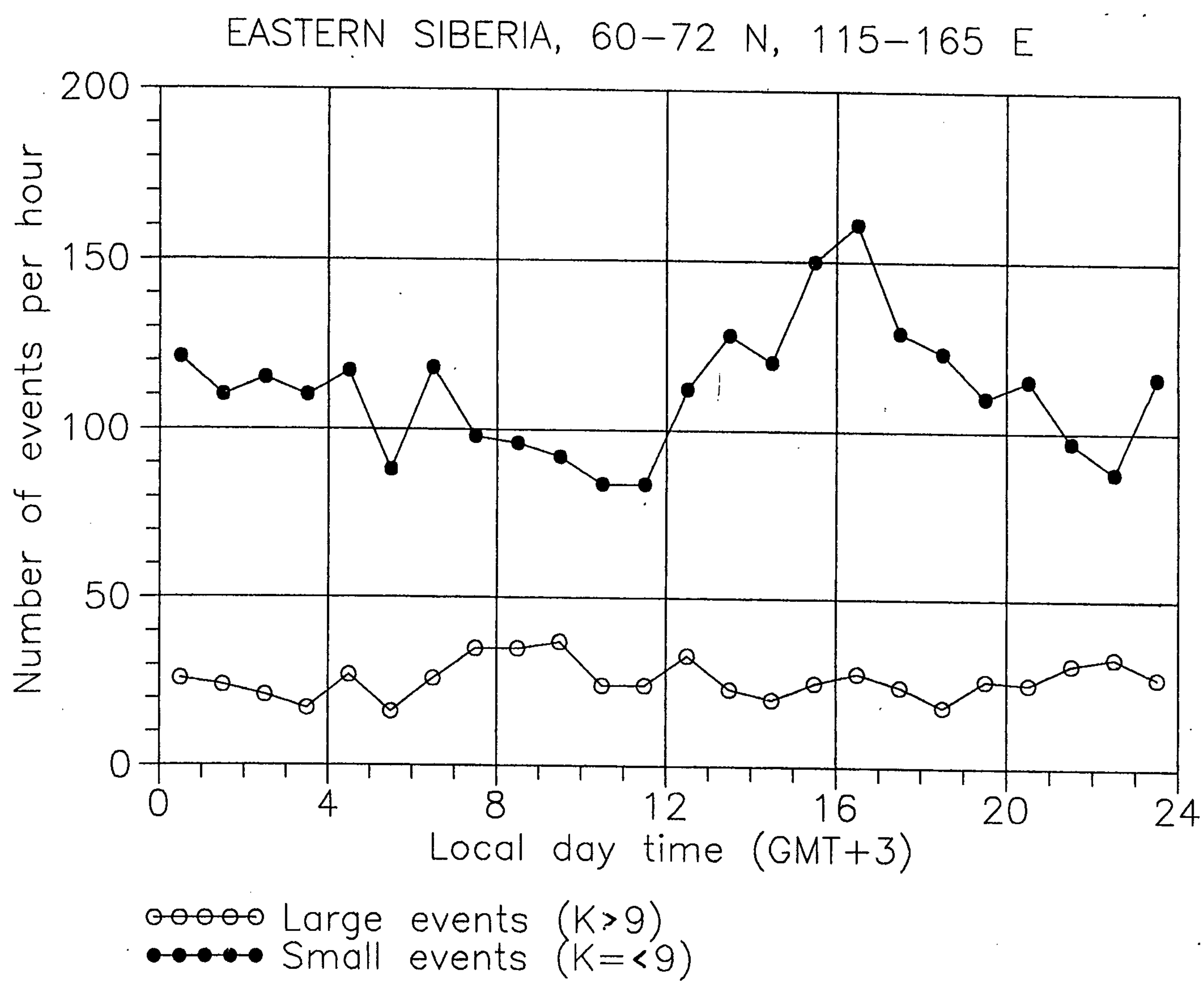

Figure 14. The local time-of-day (GMT + 3) distribution of small seismic events (K ≤ 9) in Eastern Siberia has a peak indicative of blasting activity. ESSN data for 1962 – 1990.

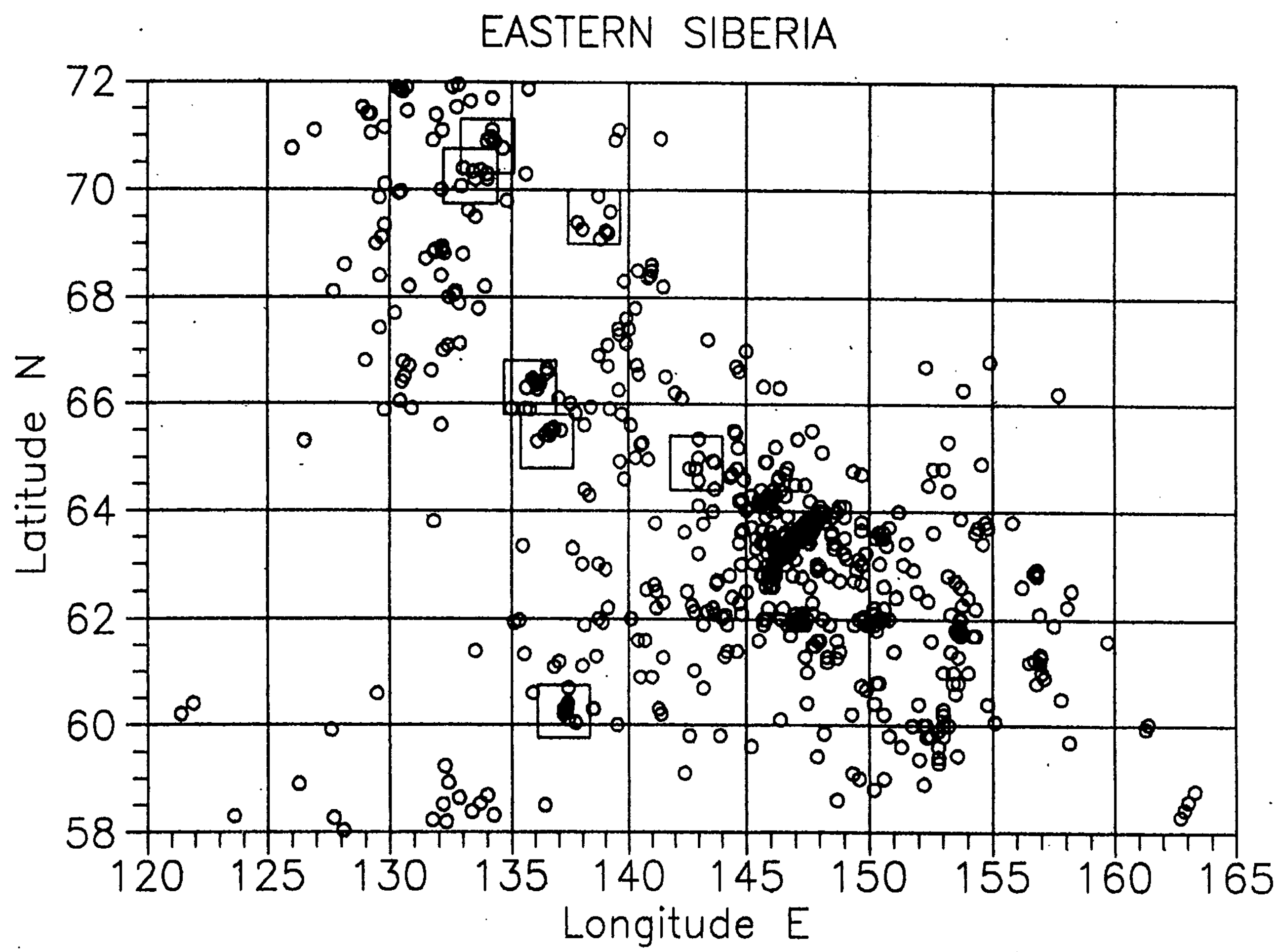

Figure 15. Map of epicenters for small events (K < 10), within the local time interval 1200 – 1700 hours. Data from ESSN. Squares mark the supposed position of blasting activity.

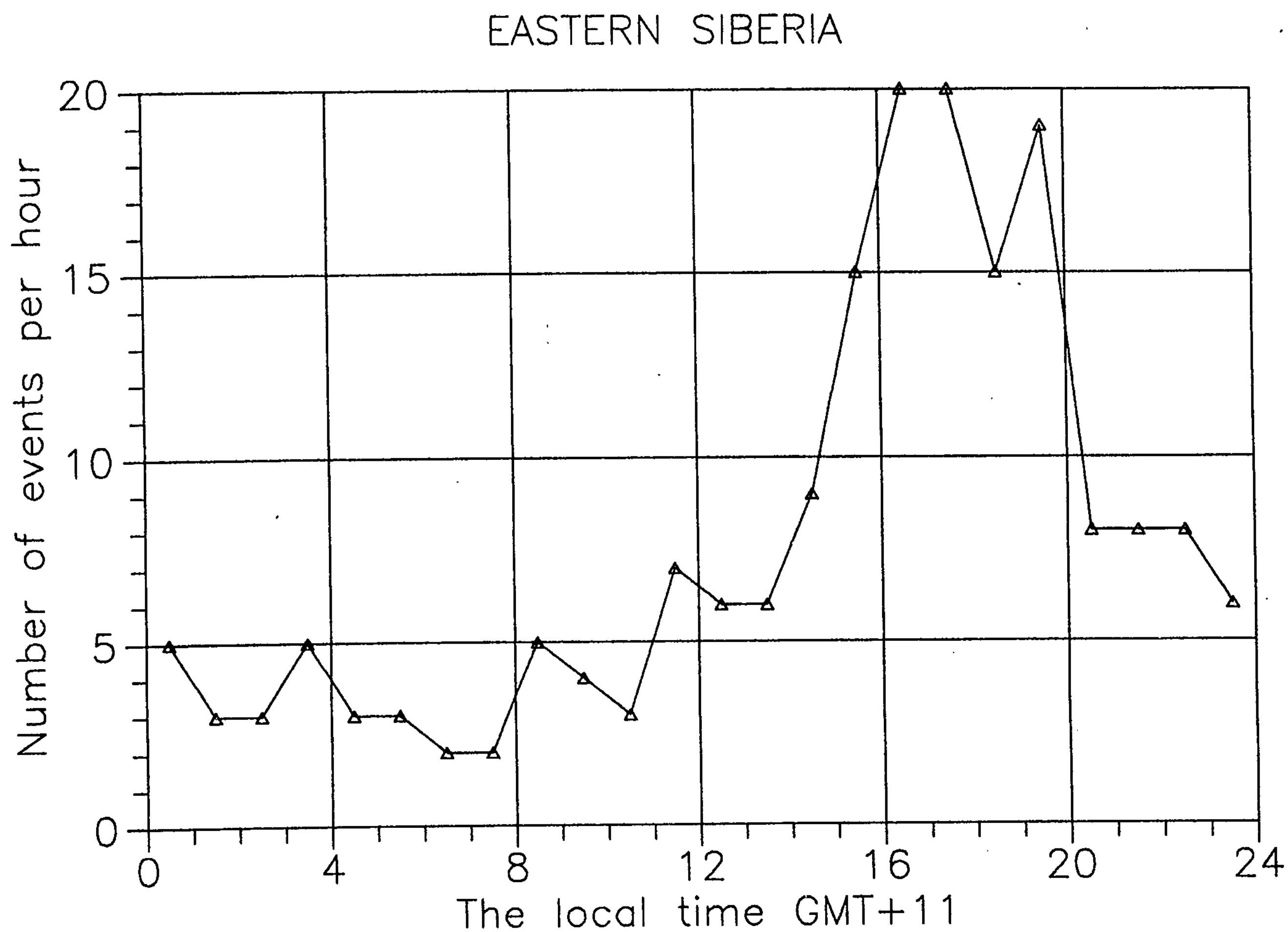

Figure 16. Distribution of small seismic events (K ≤ 9) in Eastern Siberia within the areas marked as A, B, C, supposed to be quarries or mines. Data taken mostly from ESSN, 1962 – 1990; 58–71°N, 120–165°E.

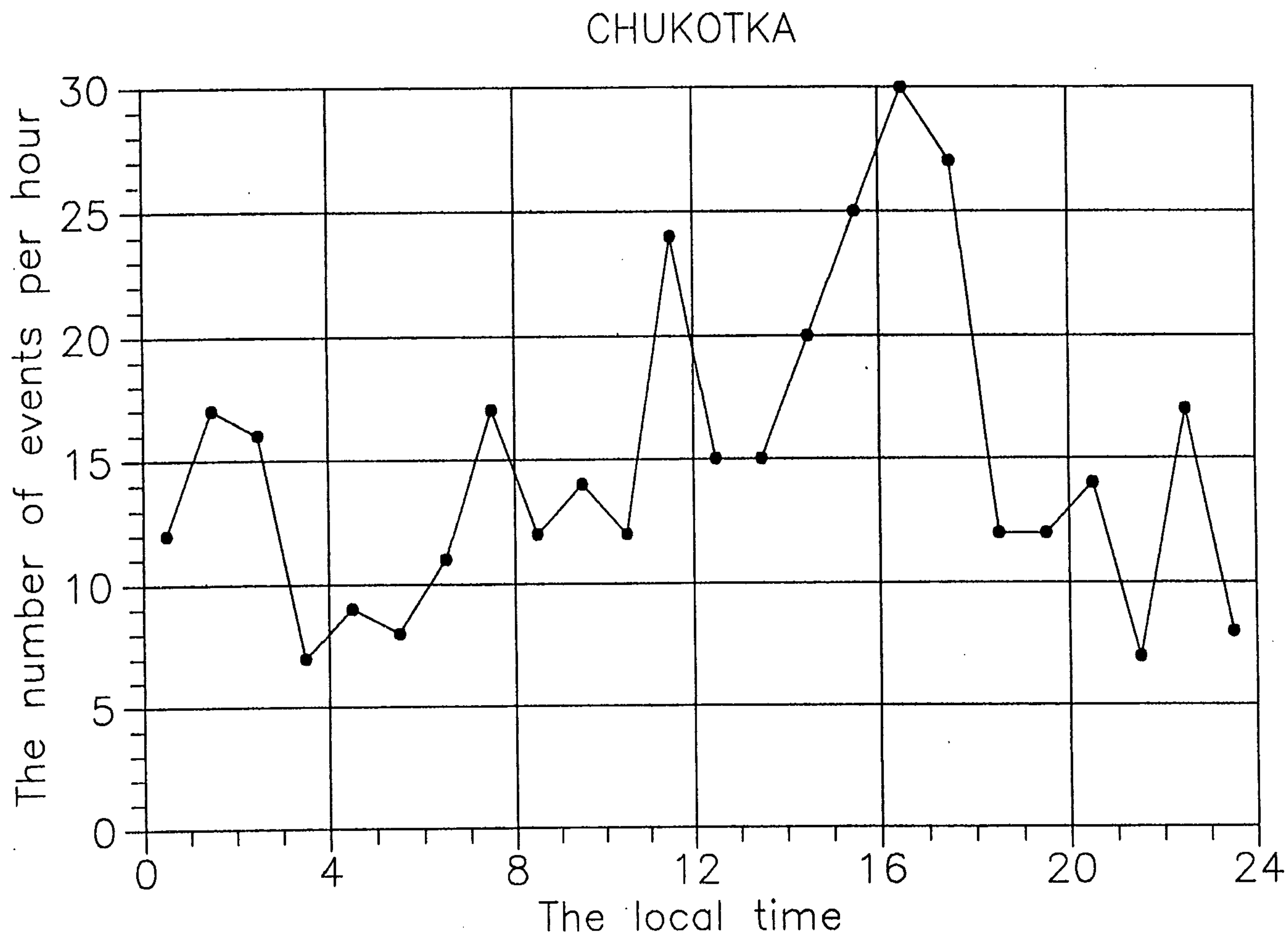

Figure 17. Distribution of seismic events in Chukotka (60–72°N, 165–195°E) vs. local time-of-day (GMT + 13). K ≤ 10. Data from ESSN catalog, 1962 – 1990.

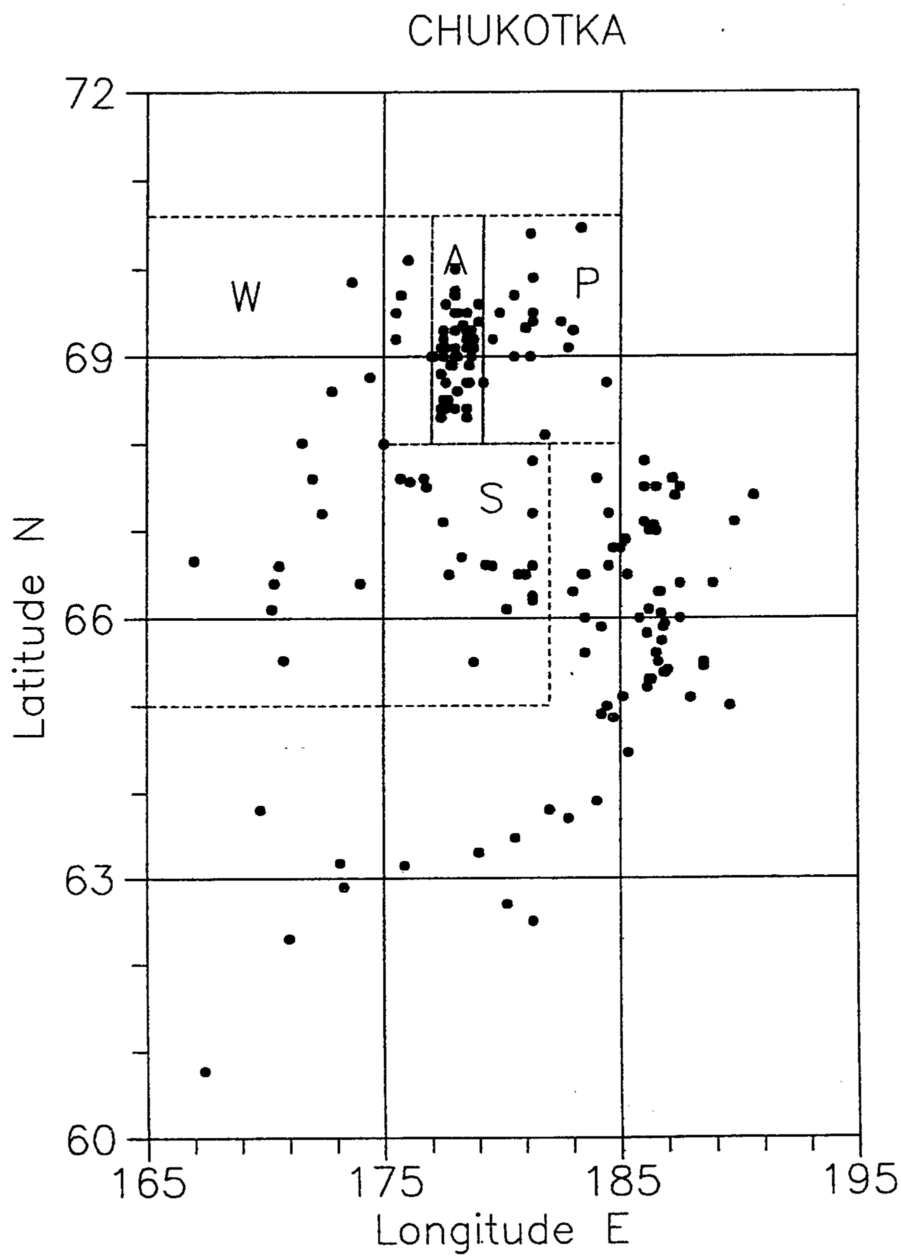

Figure 18. Map of epicenters of small (K ≤ 10) Chukotka events that occurred during the time of high blasting activity between 0700 and 1700 hours local time (see Fig. 24.2). Areas marked A, P, S, W are selected to test for seismicity that varies with time-of-day. Data are mostly from ESSN catalogs for 1962 – 1990.

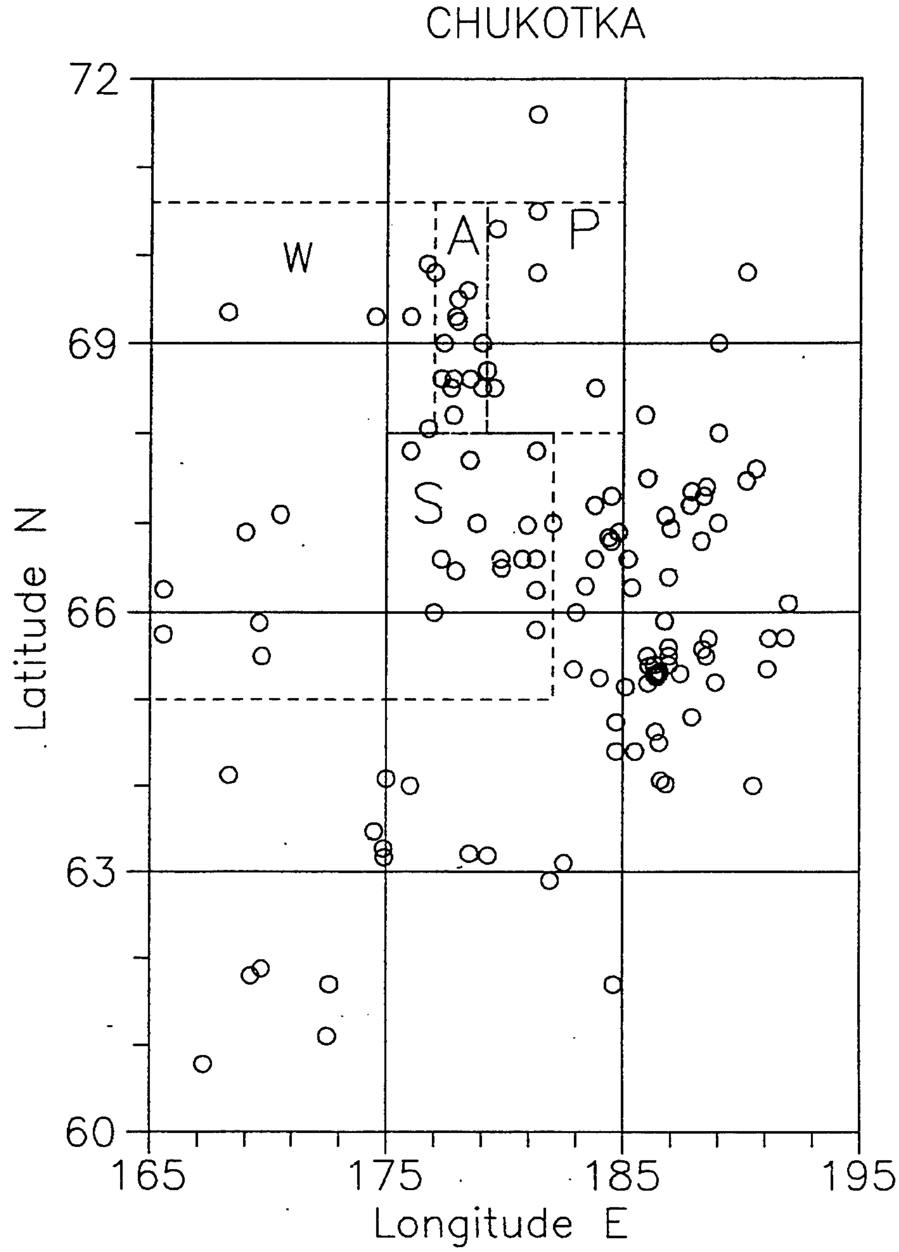

Figure 19. Map of epicenters of small (K ≤ 10) Chukotka events that occurred during the time of low blasting activity, before 0700 and after 1700 hours local time (see Fig. 24.2). Areas marked A, P, S, W still have some seismicity, but it would appear that area A has a significant number of blasts (see the high number of events for this region in Fig. 24.3.). Data are mostly from ESSN catalogs for 1962 – 1990.

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